

Greymouth Petroleum Mining Group Ltd
Kowhai-D Hydraulic Fracturing
Monitoring Programme
2018-2019

Technical Report 20-37

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Executive summary

Greymouth Petroleum Mining Group Ltd (GPL) previously known as Petrochem Ltd operates the Kowhai-D hydrocarbon exploration site located on Maunganui Road, Everett Park. This site is located in the Waitara catchment. This report outlines and discusses the results of the monitoring programme implemented by the Council in relation to hydraulic fracturing activities conducted by GPL at the wellsite over the period 22 January 2019 to 11 March 2019. The report also details the results of the monitoring undertaken and assesses the environmental effects of the Company's activities.

The programme of hydraulic fracturing undertaken by GPL at the Kowhai-D wellsite included the hydraulic fracturing of one well. The well targeted for stimulation was the Kowhai-5 well.

During the monitoring period, GPL demonstrated an overall high level of environmental performance.

The programme of monitoring implemented by the Council in relation to these hydraulic fracturing activities spanned the 2018-2019 and 2019-2020 monitoring years. Monitoring included pre and post-discharge groundwater sampling. One biomonitoring survey was also carried out on a tributary of the Waitara River prior to commencement of the hydraulic fracturing programme. Samples of hydraulic fracturing fluids, and fluids returning to the wellhead post-fracturing, were also obtained for physicochemical analysis. In order to characterise the discharges and to determine compliance with consent conditions, samples of hydraulic fracturing and return fluid were also obtained for physicochemical analysis.

This is the second monitoring report produced by the Council in relation to the hydraulic fracturing activities at the Kowhai-D wellsite.

The monitoring carried out by the Council indicates that the hydraulic fracturing activities undertaken by GPL had no significant adverse effects on local groundwater or surface water resources. There were no unauthorised incidents recording non-compliance in respect of the resource consent held by GPL in relation to these activities or provisions in regional plans, during the period under review.

GPL demonstrated a high level of environmental and administrative performance and compliance with the resource consents over the reporting period.

For reference, in the 2019-2020 year, consent holders were found to achieve a high level of environmental performance and compliance for 81% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 17% of the consents, a good level of environmental performance and compliance was achieved.

This report includes recommendations for the future monitoring of any hydraulic fracturing activities at the Kowhai-D wellsite.

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1 Introduction

1.1 Compliance monitoring programme reports and the Resource Management Act 1991

1.1.1 Introduction

This report outlines and discusses the results of the monitoring programme implemented by the Taranaki Regional Council (the Council) in relation to the programme of hydraulic fracturing undertaken by Greymouth Petroleum Mining Group Limited (GPL) at the Kowhai-D wellsite, over the period 22 January 2019 to 11 March 2019. The report also assesses the Company's level of environmental performance and compliance with the resource consent held in relation to the activity.

The programme of hydraulic fracturing undertaken by GPL at the Kowhai-D wellsite included the hydraulic fracturing of one well. The well targeted for stimulation was the Kowhai-5 well.

The programme of monitoring implemented by the Council in relation to these hydraulic fracturing activities spanned the 2017-2018 and 2018-2019 monitoring years. Monitoring included a mixture of groundwater, surface water and discharge monitoring components. This is the second monitoring report produced by the Council in relation to hydraulic fracturing activities at the Kowhai-D wellsite. The first covered hydraulic fracturing activities related to the Kowhai-4 well during the 2016-2017 and 2017-2018 monitoring years.

1.1.2 Structure of this report

Section 1 of this report is a background section. It sets out general information about:

- the nature of the monitoring programme in place for the period under review; and
- a description of the activities and operations conducted at Kowhai-D.

Section 2 presents the results of monitoring during the period under review, including scientific and technical data.

Section 3 discusses the results, their interpretations, and their significance for the environment.

Section 4 presents recommendations to be implemented for the future monitoring of any hydraulic fracturing activities at the Kowhai-D wellsite.

A glossary of common abbreviations and scientific terms, and a bibliography, are presented at the end of the report.

1.1.3 The Resource Management Act 1991 and monitoring

The Resource Management Act 1991 (RMA) primarily addresses environmental 'effects' which are defined as positive or adverse, temporary or permanent, past, present or future, or cumulative. Effects may arise in relation to:

- a. the neighbourhood or the wider community around an activity, and may include cultural and social-economic effects;
- b. physical effects on the locality, including landscape, amenity and visual effects;
- c. ecosystems, including effects on plants, animals, or habitats, whether aquatic or terrestrial;
- d. natural and physical resources having special significance (for example recreational, cultural, or aesthetic); and
- e. risks to the neighbourhood or environment.

In drafting and reviewing conditions on discharge permits, and in implementing monitoring programmes, the Council is recognising the comprehensive meaning of 'effects' inasmuch as is appropriate for each activity. Monitoring programmes are not only based on existing permit conditions, but also on the obligations of the RMA to assess the effects of the exercise of consents. In accordance with Section 35 of the RMA, the Council undertakes compliance monitoring for consents and rules in regional plans, and maintains an overview of the performance of resource users and consent holders. Compliance monitoring, including both activity and impact monitoring, enables the Council to continually re-evaluate its approach and that of consent holders to resource management and, ultimately, through the refinement of methods and considered responsible resource utilisation, to move closer to achieving sustainable development of the region's resources.

1.1.4 Evaluation of environmental and administrative performance

Besides discussing the various details of the performance and extent of compliance by the Company, this report also assigns them a rating for their environmental and administrative performance during the period under review.

Environmental performance is concerned with actual or likely effects on the receiving environment from the activities during the monitoring year. Administrative performance is concerned with the Company's approach to demonstrating consent compliance in site operations and management including the timely provision of information to Council (such as contingency plans and water take data) in accordance with consent conditions.

Events that were beyond the control of the consent holder and unforeseeable (that is a defence under the provisions of the RMA can be established) may be excluded with regard to the performance rating applied. For example loss of data due to a flood destroying deployed field equipment.

The categories used by the Council for this monitoring period, and their interpretation, are as follows:

Environmental Performance

High: No or inconsequential (short-term duration, less than minor in severity) breaches of consent or regional plan parameters resulting from the activity; no adverse effects of significance noted or likely in the receiving environment. The Council did not record any verified unauthorised incidents involving environmental impacts and was not obliged to issue any abatement notices or infringement notices in relation to such impacts.

Good: Likely or actual adverse effects of activities on the receiving environment were negligible or minor at most. There were some such issues noted during monitoring, from self reports, or during investigations of incidents reported to the Council by a third party but these items were not critical, and follow-up inspections showed they have been dealt with. These minor issues were resolved positively, co-operatively, and quickly. The Council was not obliged to issue any abatement notices or infringement notices in relation to the minor non-compliant effects; however abatement notices may have been issued to mitigate an identified potential for an environmental effect to occur.

For example:

- High suspended solid values recorded in discharge samples, however the discharge was to land or to receiving waters that were in high flow at the time;
- Strong odour beyond boundary but no residential properties or other recipient nearby.

Improvement required: Likely or actual adverse effects of activities on the receiving environment were more than minor, but not substantial. There were some issues noted during monitoring, from self reports, or during investigations of incidents reported to the Council by a third party. Cumulative

adverse effects of a persistent minor non-compliant activity could elevate a minor issue to this level. Abatement notices and infringement notices may have been issued in respect of effects.

Poor: Likely or actual adverse effects of activities on the receiving environment were significant. There were some items noted during monitoring, from self reports, or during investigations of incidents reported to the Council by a third party. Cumulative adverse effects of a persistent moderate non-compliant activity could elevate an 'improvement required' issue to this level. Typically there were grounds for either a prosecution or an infringement notice in respect of effects.

Administrative performance

High: The administrative requirements of the resource consents were met, or any failure to do this had trivial consequences and were addressed promptly and co-operatively.

Good: Perhaps some administrative requirements of the resource consents were not met at a particular time, however this was addressed without repeated interventions from the Council staff. Alternatively adequate reason was provided for matters such as the no or late provision of information, interpretation of 'best practical option' for avoiding potential effects, etc.

Improvement required: Repeated interventions to meet the administrative requirements of the resource consents were made by Council staff. These matters took some time to resolve, or remained unresolved at the end of the period under review. The Council may have issued an abatement notice to attain compliance.

Poor: Material failings to meet the administrative requirements of the resource consents. Significant intervention by the Council was required. Typically there were grounds for an infringement notice.

For reference, in the 2019-2020 year, consent holders were found to achieve a high level of environmental performance and compliance for 81% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 17% of the consents, a good level of environmental performance and compliance was achieved.¹

1.2 Process description

1.2.1 Hydraulic fracturing

Hydraulic fracturing is a reservoir stimulation technique used to increase the flow of hydrocarbons to the surface. The primary objective of hydraulic fracturing is to increase the permeability of the target reservoir by creating numerous small, interconnected fractures, thus increasing the flow of hydrocarbons from the formation to a given well. The process of hydraulic fracturing has enabled companies to produce hydrocarbons at economically viable rates from extremely low permeability reservoirs and those that have become depleted using conventional production techniques.

The process of hydraulic fracturing involves the pumping of fluids and a proppant (medium-grained sand or small ceramic pellets) down a well, through a perforated section of the well casing, and into the target reservoir. The fluid mixture is pumped at a pressure that exceeds the fracture strength of the reservoir rock in order to create fractures. Once fractures have been initiated, pumping continues in order to force the fluid and proppant into the fractures created. The proppant is designed to keep the fractures open when the

¹ The Council has used these compliance grading criteria for 15 years. They align closely with the 4 compliance grades in the MfE Best Practice Guidelines for Compliance, Monitoring and Enforcement, 2018

pumping is stopped. The placement of proppant into the fractures can be assisted by the use of cross-linked gels (gel fracturing), turbulent flow (slick-water fracturing) or the use of nitrogen gas.

1.2.1.1 Gel fracturing

Gel fracturing utilises cross-linked gel solutions, which are liquid at the surface but, when mixed, form long-chain polymer bonds and thus become viscous gels. These gels are used to transport the proppant into the formation. Once in the formation they 'break' back with time, temperature and the aid of gel breaking chemicals into a liquid state and are flowed back to surface, without disturbing the proppant which remains in place and enhances the flow of hydrocarbons back to the surface.

1.2.1.2 Slick water fracturing

Slick water fracturing utilises water based fracturing fluids with friction-reducing additives. The addition of the friction reducers allows the fracturing fluids and proppant to be pumped to the target zone at higher rates and reduced pressures, than when using water alone. The higher rate creates turbulence within the fluid column holding the proppant and enabling its placement into the open fractures and enhancing the flow of hydrocarbons back to the surface.²

1.2.1.3 Nitrogen gas fracturing

Nitrogen gas assisted fracturing involves replacing some of the fluid used in the fracturing process with nitrogen gas, which can fracture rock at high pressures much like water. While nitrogen (N₂) is a gas at room temperature, it can be maintained in a liquid state through cooling and pressurisation. Nitrogen assisted fracturing is extremely beneficial from a production standpoint as inevitably during the fracturing process some of the water pumped down the well remains underground in the rock formation, which can block some of the small pores inhibiting hydrocarbon recovery. Nitrogen gas achieves the same purpose as water but returns more easily to the surface.³ More indirectly, a reduction in the volume of water used also reduces the total concentration of chemical additives required and the volume of water returning to the surface that requires subsequent disposal.²

1.2.2 The Kowhai-D wellsite and hydraulic fracturing activities

The Kowhai-D wellsite is located on Maunganui Road, Everett Park and lies within the Waitara catchment. The wellsite is sited around 50 m south west of an unnamed tributary of the Waitara River. The Waitara River itself is located approximately 580 m north east of the wellsite boundary. The location of the wellsite is illustrated in Figure 1. A summary of the hydraulic fracturing activities carried out by GPL in the Kowhai-5 well at the Kowhai-D wellsite during the period being reported is provided below in Table 1.

Table 1 Summary of hydraulic fracturing details

| Well | Bore id. | Date | Interval | Injection zone (m TVDss) | Formation |
|----------|----------|------------|----------|--------------------------|-----------|
| Kowhai-5 | GND2829 | 22/01/2019 | 1 | 4089.4-4098.4 | Mangahewa |
| | | 14/02/2019 | 2 | 4057.5-4060.5 | |
| | | 11/03/2019 | 3 | 3607.5-3610.5 | |

² <http://geology.com/energy/hydraulic-fracturing-fluids>

³ <http://frackwire.com/nitrogen-gas-fracking>



Figure 1 Location map

1.3 Resource consents

1.3.1 Discharges of wastes to land

Sections 15(1)(b) and (d) of the RMA stipulate that no person may discharge any contaminant onto land if it may then enter water, or from any industrial or trade premises onto land under any circumstances, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations.

The Company holds one resource consent the details of which are summarised in Table 2 below. Summaries of the conditions attached to the permit are set out in Section 3 of this report.

A summary of the various consent types issued by the Council is included Appendix I, as is a copy of the permit held by the Company during the period under review.

Table 2 Resource consent held by the Company during the period under review

| Consent number | Purpose of consent | Granted | Next review | Expires |
|----------------|---|------------|-------------|-----------|
| 10297-1 | To discharge water based hydraulic fracturing fluids into land at depths greater than 3,385 m TVDss beneath the Kowhai-D wellsite | 24/05/2016 | June 2021 | 1/06/2033 |

1.4 Monitoring programme

1.4.1 Introduction

Section 35 of the RMA sets obligations upon the Council to gather information, monitor and conduct research on the exercise of resource consents within the Taranaki region. The Council is also required to assess the effects arising from the exercising of these consents and report upon them.

The Council may therefore make and record measurements of physical and chemical parameters, take samples for analysis, carry out surveys and inspections, conduct investigations and seek information from consent holders.

The monitoring programme for the Kowhai-D wellsite consisted of four primary components.

1.4.2 Programme liaison and management

There is generally a significant investment of time and resources by the Council in:

- ongoing liaison with resource consent holders over consent conditions and their interpretation and application;
- in discussion over monitoring requirements;
- preparation for any consent reviews, renewals or new consent applications;
- advice on the Council's environmental management strategies and content of regional plans; and
- consultation on associated matters.

1.4.3 Assessment of data submitted by the consent holder

As required by the conditions of consent 10297-1, GPL submitted pre and post-fracturing discharge reports to the Council for the well fractured during the period under review. Pre-fracturing discharge reports provide an outline of the proposed fracturing operations in relation to each well, while post-fracturing

reports confirm details of what actually occurred. The specific range of information required in each report is stipulated in the conditions of the consent.

1.4.4 Physiochemical sampling

1.4.4.1 Groundwater

As a generally accepted rule, all existing bores or wells within a 1 km radius of a hydraulic fracturing activity are assessed for their suitability for sampling (or otherwise) and included in the monitoring programme for the wellsite.

A survey of local groundwater bores and wells was carried out, with no existing groundwater bores or wells existing bores or wells identified within 1 km radius of the Kowhai-D wellsite.

Given the lack of suitable existing groundwater sites for monitoring within the survey area, a purpose built monitoring bore (GND2632) was drilled by GPL in order to comply with condition 7 of the consent. The bore details are summarised in Table 3. The location of the bore is displayed in Figure 1. GND2632 is the only groundwater monitoring site included in the monitoring programme.

Table 3 Details of groundwater sites included in the monitoring programme

| Monitoring site | Eastings (NZTM) | Northings (NZTM) | Distance from wellsite (m) | Total depth (m) | Screened/open interval (m) | Aquifer |
|-----------------|-----------------|------------------|----------------------------|-----------------|----------------------------|---------------------------------|
| GND2632 | 1710181 | 4674906 | <50 | 27 | 18-27 | Volcanics and fluvial sediments |

Samples of groundwater were obtained pre-fracturing to provide a baseline reference of groundwater composition, with further rounds of sampling carried out two months, seven months and 11 months after the commencement of activities.

1.4.4.2 Hydraulic fracturing and return fluids

In addition to the sampling of local groundwater, representative samples of the hydraulic fracturing fluid and reservoir fluids produced back to the wellhead immediately following each fracturing event (return fluids) were obtained for analysis.

Samples of return fluids were collected at regular intervals during the flow-back period. Return fluids are comprised of a mixture of hydraulic fracturing fluids and formation fluids produced from the target reservoir, following the completion of the hydraulic fracturing process. The relative concentrations of each contributing fluid type change as the volume of fluid produced from the well increases. Immediately following the opening of the well post-fracturing, a high proportion of the fluid returning to the wellhead is fluid injected during the hydraulic fracturing process. As the volume of fluid produced from the well increases, the proportion of hydraulic fracturing fluid reduces in relation to formation fluids. The individual samples of return fluid are generally combined in a composite sample for laboratory analysis. Composites are designed to provide a representative sample of fluids returning to the wellhead over the entire flow-back period.

All samples were transported to Hill laboratories (Hills) for analysis following standard chain of custody procedures.

1.4.5 Surface water quality monitoring

The wellsite is sited around 50 m south west of an unnamed tributary of the Waitara River. The Waitara River itself is located approximately 580 m north east of the wellsite boundary.

Stormwater and treated site water are discharged onto land and into the unnamed tributary of the Waitara River at the wellsite. Sites have been selected to monitor upstream and downstream of the site and the estimated location of groundwater/subsurface drainage from the discharge area. Details of the three sites to be monitored on the unnamed tributary are included in Table 4. The locations are illustrated on Figure 1.

Table 4 Surface water monitoring site details

| Monitoring site | Description | Location | Eastings | Northings |
|-----------------|--|--------------------------------------|----------|-----------|
| WTR000743 | Tributary of the Waitara River upstream of Kowhai-D wellsite | 5 m upstream of a track to farm shed | 1710423 | 5674733 |
| WTR000744 | Tributary of the Waitara River downstream of Kowhai-D wellsite | Downstream edge of wetland | 1710095 | 5675012 |
| WTR000745 | Tributary of the Waitara River downstream of Kowhai-D wellsite | 50 m downstream of wetland | 1710042 | 5675020 |

1.4.5.1 Biomonitoring surveys

Biomonitoring surveys are undertaken to determine whether stormwater discharges from the wellsite have had any detrimental impacts on the macroinvertebrate communities of the tributary of the Waitara River. Samples are processed to provide number of taxa (richness), MCI and SQMCI₅ scores, and EPT taxa for each site.

The MCI is a measure of the overall sensitivity of the macroinvertebrate community to the effects of organic pollution in stony streams. It is based on the presence/absence of taxa with varying degrees of sensitivity to environmental conditions. The SQMCI₅ takes into account taxa abundance as well as sensitivity to pollution, and may reveal more subtle changes in communities. It may be the more appropriate index if non-organic impacts are occurring.

Significant differences in either the MCI or the SQMCI₅ between sites indicate the degree of adverse effects (if any) of the discharges being monitored.

One macroinvertebrate survey was carried out prior to commencement of fracturing the Kowhai-5 well on 26 November 2018. A post-fracturing survey could not be undertaken as the necessary flow conditions⁴ were not met within the required timeframe.

⁴ A period of up to 10 days is required between rainfall events to meet the necessary flow conditions to enable a robust survey to be undertaken.

2 Results

2.1 Consent holder submitted data

2.1.1 Kowhai-5 post-fracturing discharge report

The conclusions from the Kowhai-5 post-fracturing discharge report are summarised as follows:

- A total of three of the eight zones planned were fractured over the period 22 January 2019 to 11 March 2019 at depths between 3,607 to 4,098 m TVDss.
- A total of 4,251 bbls (676 m³) of liquid was discharged across the three fractured zones. The total proppant weight was 127 tonnes (279,996 lbs).
- The Kowhai-5 well was opened for flow-back following the completion of fracturing operations. In total 14,656 bbls (2,330 m³) of fluid was returned from the well over the initial flow-back period.
- Zone 3 returned slightly less fluid than injected, with 42.6 bbls (6.7 m³) of the 1,078 bbls (171 m³) of fluid injected estimated to have remained within the formation. Zone 2 returned significantly more fluid (10,742 bbls or 1,708 m³) than injected (1,594 bbls or 253 m³).
- No screen outs occurred.
- All return fluid from the Kowhai-5 fracturing operations was disposed of by deep well injection at the Kaimiro-G wellsite under consent 9470-1.
- Pressure testing was undertaken of all surface equipment, including flow lines and the wellhead, prior to injection.
- There was no escape of fluids during hydraulic fracturing operations.
- There were no seismic events reported by GPL within a 5 km radius (in three dimensions) of the discharge location over the 72 hour period following hydraulic fracturing.
- It is considered that the mitigation measures implemented by GPL were effective in reducing the potential for adverse environmental effects associated with fracturing operations.

2.2 Physiochemical sampling

2.2.1 Groundwater

Hydraulic fracturing activities commenced at the Kowhai-D wellsite on 22 January 2019 and continued until 11 March 2019. A pre-fracturing baseline sample was collected on 30 August 2018. Post-fracturing groundwater samples were collected three months, seven months and 11 months following commencement of the activities on 29 March 2019, 19 August 2019 and 10 December 2019 respectively.

Methane concentrations >1 gm³ and trace ethane were reported in all samples both pre and post-hydraulic fracturing activities and can occur as a result of biogenic processes in sulphate depleted groundwater systems. To determine whether the source of the methane was biogenic or thermogenic, samples were sent to Geological and Nuclear Sciences (GNS) for carbon 13 isotope analysis. The presence of carbon 13 isotopes concentrations at less than -50‰ indicate a thermogenic deep gas source and concentrations greater than -50‰ a shallow biogenic gas source. Carbon 13 concentrations ranged between -61.7 to -67.1 ‰ indicating the source of methane was predominantly biogenic and within the expected ranges for shallow groundwater across Taranaki.

As traces of ethane were also reported in the samples a wetness ratio⁵ of methane to ethane can also be used to give an indication of the source of the dissolved gases. Lower ratios (<1,000) can be indicative of a potential thermogenic gas source.

The wetness ratios calculated ranged between 1,075 and 1,238 indicating that the shallow groundwater resources at the site are influenced by a biogenic gas source.

Overall, samples demonstrate relatively narrow ranges between analyte concentrations over time. The subtle variation in analyte concentrations at each site are a result of natural seasonal fluctuation and sampling variability. The results of the laboratory analysis indicate there have been no significant changes in groundwater composition over the period monitored.

A summary of the results for groundwater samples taken in relation to the hydraulic fracturing activities compared to baseline is included in Table 5. The certificates of analysis for the review period are included in Appendix II.

Table 5 Results of groundwater sampling carried out in relation to the Kowhai-5 fracturing event

| Parameter | Bore id | GND2632 | | | |
|----------------------------|------------------------------------|------------|-----------------|-----------------|------------------|
| | Type | Pre-frac | 3 mth post-frac | 7 mth post-frac | 11 mth post-frac |
| Sample date | - | 30/08/2018 | 29/03/2019 | 19/08/2019 | 10/12/2019 |
| Sample time | NZST | 12:15 | 9:15 | 12:10 | 11:25 |
| Lab number (TRC) | Unit | 183458 | 191620 | 192969 | 194424 |
| pH | pH | 8.2 | 8.2 | 8.2 | 8.2 |
| Total alkalinity | g/m ³ CaCO ₃ | 148 | 148 | 150 | 148 |
| Bicarbonate | g/m ³ HCO ₃ | 178 | 177 | 180 | 177 |
| Total hardness | g/m ³ CaCO ₃ | 84 | 83 | 84 | 93 |
| Electrical conductivity | mS/m | 31.3 | 32.2 | 31.8 | 30.6 |
| Total dissolved solids | g/m ³ | 180 | 182 | 169 | 175 |
| Dissolved calcium | g/m ³ | 19.4 | 20 | 21 | 21 |
| Chloride | g/m ³ | 12.0 | 11.6 | 11.7 | 11.8 |
| Dissolved magnesium | g/m ³ | 8.7 | 7.9 | 8.0 | 9.5 |
| Dissolved potassium | g/m ³ | 3.1 | 3.1 | 3.0 | 3.2 |
| Dissolved sodium | g/m ³ | 33 | 32 | 33 | 34 |
| Nitrite nitrogen | g/m ³ N | < 0.002 | < 0.002 | < 0.002 | < 0.002 |
| Nitrate nitrogen | g/m ³ N | < 0.002 | < 0.002 | < 0.002 | < 0.002 |
| Nitrate & nitrite nitrogen | g/m ³ N | < 0.002 | < 0.002 | < 0.002 | < 0.002 |
| Sulphate | g/m ³ | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| Dissolved barium | g/m ³ | 0.006 | < 0.005 | 0.005 | < 0.005 |

⁵ Biogenic gas is formed at shallow depths and low temperatures by anaerobic decomposition of organic matter, this gas is lacking in C₂+ hydrocarbons i.e. it is very dry. Thermogenic gas is formed at deeper depths by thermal cracking of organic matter into petroleum liquids and wet gas.

| Parameter | Bore id | GND2632 | | | |
|----------------------|------------------|------------|-----------------|-----------------|------------------|
| | Type | Pre-frac | 3 mth post-frac | 7 mth post-frac | 11 mth post-frac |
| Sample date | - | 30/08/2018 | 29/03/2019 | 19/08/2019 | 10/12/2019 |
| Sample time | NZST | 12:15 | 9:15 | 12:10 | 11:25 |
| Lab number (TRC) | Unit | 183458 | 191620 | 192969 | 194424 |
| Dissolved bromine | g/m ³ | - | - | - | - |
| Bromide | g/m ³ | 0.07 | 0.08 | 0.07 | 0.06 |
| Dissolved copper | g/m ³ | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0005 |
| Dissolved iron | g/m ³ | 0.04 | 0.04 | 0.04 | 0.04 |
| Dissolved manganese | g/m ³ | 0.0091 | 0.0084 | 0.0091 | 0.0087 |
| Dissolved mercury | g/m ³ | < 0.00008 | < 0.00008 | < 0.00008 | < 0.00008 |
| Dissolved Nickel | g/m ³ | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0005 |
| Dissolved zinc | g/m ³ | < 0.0010 | 0.0073 | 0.0083 | < 0.0010 |
| Ethylene glycol | g/m ³ | < 4 | < 4 | < 4 | < 4 |
| Propylene glycol | g/m ³ | < 4 | < 4 | < 4 | < 4 |
| Methanol | g/m ³ | < 2 | < 2 | < 2 | < 2 |
| Benzene | g/m ³ | < 0.0010 | < 0.0010 | < 0.0010 | < 0.0010 |
| Toluene | g/m ³ | < 0.0010 | < 0.0010 | < 0.0010 | < 0.0010 |
| Ethylbenzene | g/m ³ | < 0.0010 | < 0.0010 | < 0.0010 | < 0.0010 |
| m-Xylene | g/m ³ | < 0.002 | < 0.002 | < 0.002 | < 0.002 |
| o-Xylene | g/m ³ | < 0.0010 | < 0.0010 | < 0.0010 | < 0.0010 |
| Formaldehyde | g/m ³ | < 0.02 | < 0.02 | < 0.02 | < 0.02 |
| Ethane | g/m ³ | 0.008 | 0.008 | 0.008 | 0.008 |
| Ethylene | g/m ³ | < 0.004 | < 0.004 | < 0.004 | < 0.004 |
| Methane | g/m ³ | 8.6 | 9.2 | 9.9 | 9.4 |
| C7-C9 hydrocarbons | g/m ³ | <0.06 | <0.006 | <0.006 | <0.006 |
| C10-C14 hydrocarbons | g/m ³ | < 0.2 | < 0.2 | < 0.2 | < 0.2 |
| C15-C36 hydrocarbons | g/m ³ | < 0.4 | < 0.4 | < 0.4 | < 0.4 |
| Total hydrocarbons | g/m ³ | < 0.7 | < 0.7 | < 0.7 | < 0.7 |
| δ13C value | ‰ (-) | 67.1 | 64.5 | 61.7 | 64.9 |

2.2.2 Hydraulic fracturing and return fluids

The results of the analyses carried out on samples of the hydraulic fracturing fluid used in the treatment of the Kowhai-5 well are shown below in Table 6. The certificates of analysis are included in Appendix III.

The results of the analyses carried out on the return fluid samples obtained following the hydraulic fracturing of the Kowhai-5 well are summarised below in Table 7 and certificates of analysis are included in Appendix III. The results demonstrate the variability of groundwater composition and hydrocarbon concentrations with depth. The relatively high levels of chloride, sodium and hydrocarbons in each sample

indicate that the composite samples prepared contained a greater proportion of reservoir fluids than hydraulic fracturing fluids introduced during the fracturing activities, which are comprised predominantly of freshwater.

Table 6 Results of hydraulic fracturing fluid sampling

| Parameter | Bore id | GND2829 | | |
|----------------------|------------------|------------------|-------------|-------------|
| | Unit | Fracturing fluid | | |
| Reference | - | Treatment 1 | Treatment 2 | Treatment 3 |
| Sample date | - | 22/01/2019 | 14/02/2019 | 11/03/2019 |
| Lab number | Hill | 2113937 | 2129322 | 2143163 |
| Ethylene glycol* | g/m ³ | <20 | <4 | <20 |
| Propylene glycol* | g/m ³ | <20 | <4 | <20 |
| Methanol | g/m ³ | <20 | <30 | <20 |
| Benzene | g/m ³ | <0.010 | <0.010 | <0.010 |
| Toluene | g/m ³ | <0.010 | <0.010 | <0.010 |
| Ethylbenzene | g/m ³ | <0.010 | <0.010 | <0.010 |
| m-Xylene | g/m ³ | <0.02 | <0.02 | <0.02 |
| o-Xylene | g/m ³ | <0.010 | <0.010 | <0.010 |
| C7-C9 hydrocarbons | g/m ³ | <0.6 | <0.6 | <0.6 |
| C10-C14 hydrocarbons | g/m ³ | 2,300 | 2,000 | 3,000 |
| C15-C36 hydrocarbons | g/m ³ | 210 | 167 | 230 |
| Total hydrocarbons | g/m ³ | 2,500 | 2,200 | 3,300 |

Note * Depending on the viscosity of the sample received at the laboratory, samples may require dilution prior to analysis which results in higher detection limits.

Table 7 Results of hydraulic fracturing return fluid sampling

| Parameter | Bore id | GND2829 | | |
|-------------------------|------------------------------------|--------------|-------------|-------------|
| | Unit | Return fluid | | |
| Reference | - | Treatment 1 | Treatment 2 | Treatment 3 |
| Lab number | Hill | 2116008 | 2129321 | 2171287 |
| pH | pH | 6.6 | 6.7 | 7.8 |
| Total alkalinity | g/m ³ CaCO ₃ | 620 | 600 | 1140 |
| Bicarbonate | g/m ³ HCO ₃ | 543 | 530 | 904 |
| Total hardness | g/m ³ CaCO ₃ | 400 | 350 | 176 |
| Electrical conductivity | mS/m | 2,160 | 1,921 | 1,526 |
| Total dissolved solids | g/m ³ | 13,600 | 13,100 | 11,600 |
| Dissolved barium | g/m ³ | 83 | 66 | 41 |
| Dissolved bromine | g/m ³ | 21 | 18.2 | 15.6 |
| Dissolved calcium | g/m ³ | 136 | 120 | 52 |

| Parameter | Bore id | GND2829 | | |
|----------------------------|--------------------|--------------|-------------|-------------|
| | Unit | Return fluid | | |
| Reference | - | Treatment 1 | Treatment 2 | Treatment 3 |
| Lab number | Hill | 2116008 | 2129321 | 2171287 |
| Dissolved copper | g/m ³ | 0.018 | 0.032 | 0.036 |
| Dissolved iron | g/m ³ | 3.9 | 11.5 | 25.0 |
| Dissolved magnesium | g/m ³ | 14 | 13 | 11 |
| Dissolved manganese | g/m ³ | 5.2 | 3.9 | 1.4 |
| Total Nickel | g/m ³ | 0.08 | 0.24 | 0.27 |
| Total potassium | g/m ³ | 260 | 250 | 175 |
| Total sodium | g/m ³ | 4,300 | 3,800 | 3,100 |
| Total sulphur | g/m ³ | 24 | 29 | 34 |
| Total zinc | g/m ³ | 0.14 | 0.65 | 0.23 |
| Chloride | g/m ³ | 6,900 | 6,900 | 4,700 |
| Nitrite nitrogen | g/m ³ N | <0.0010 | <0.10 | <0.00110 |
| Nitrate nitrogen | g/m ³ N | 0.0027 | <0.10 | <0.0010 |
| Nitrate & nitrite nitrogen | g/m ³ N | 0.012 | <0.5 | <0.0010 |
| Sulphate | g/m ³ | 73 | 87 | 101 |
| Ethylene glycol* | g/m ³ | <20 | <20 | <50 |
| Propylene glycol* | g/m ³ | <20 | <20 | <50 |
| Methanol | g/m ³ | <20 | <30 | <20 |
| Benzene | g/m ³ | 12 | 20 | 24 |
| Toluene | g/m ³ | 18.4 | 34 | 165 |
| Ethylbenzene | g/m ³ | 2.3 | 7.8 | 65.0 |
| m-Xylene | g/m ³ | 10.4 | 22.0 | 340.0 |
| o-Xylene | g/m ³ | 3.7 | 7.5 | 131.0 |
| Formaldehyde | g/m ³ | <1.5 | <0.2 | <0.2 |
| C7-C9 hydrocarbons | g/m ³ | 96 | 148 | 3,000 |
| C10-C14 hydrocarbons | g/m ³ | 670 | 990 | 4,300 |
| C15-C36 hydrocarbons | g/m ³ | 280 | 890 | 3,300 |
| Total hydrocarbons | g/m ³ | 1,050 | 2,000 | 10,600 |

Note * Depending on the viscosity of the sample received at the laboratory, samples may require dilution prior to analysis which results in higher detection limits.

2.3 Biomonitoring surveys

One macroinvertebrate survey was carried out at three sites in an unnamed tributary of the Waitara River, located approximately 50 m from the Kowhai-D wellsite prior to the commencement of hydraulic fracturing activities. Following completion of hydraulic fracturing at the Kowhai-D wellsite the flow conditions that

enable a robust survey to be undertaken were not met within the required timeframe. Consequently a post-fracturing survey could not be undertaken.

The results of the pre-fracturing survey indicated a higher MCI and SQMCI score at site 1, the upstream 'control' site compared to sites 2 and 3, both of which have the potential to be impacted by discharges from the Kowhai-D wellsite. However, given that both the MCI score and SQMCI score were both significantly higher than any previously recorded scores at this site, it is likely that this represents an improvement in habitat and/or water quality at site 1, rather than any adverse effects from the Kowhai-D wellsite.

Furthermore, the taxa richness and MCI scores at sites 2 and 3 were similar to previously recorded scores at these sites, providing further evidence that no recent adverse effects had occurred as a result of discharges from the Kowhai-D wellsite.

As a result of flow conditions no post-fracturing survey could be carried out within the required timeframe. As a result, it was not possible to make any direct comparisons between results pre and post the activities. However, previous surveys were carried out at the site on 16 February 2017, 26 April 2017 and 29 November 2017 in relation to hydraulic fracturing of the Kowhai-4 well. These surveys provided no evidence that discharges from the Kowhai-D wellsite had caused any significant detrimental impacts on the macroinvertebrate communities of the unnamed tributary.

A Copy of the biomonitoring report for the site is available from the Council upon request.

2.4 Investigations, interventions, and incidents

The monitoring programme for the year was based on what was considered to be an appropriate level of monitoring, review of data, and liaison with GPL. During the year matters may arise which require additional activity by the Council, for example provision of advice and information, or investigation of potential or actual causes of non-compliance or failure to maintain good practices. A pro-active approach that in the first instance avoids issues occurring is favoured.

The Council operates and maintains a register of all complaints or reported and discovered excursions from acceptable limits and practices, including non-compliance with consents, which may damage the environment. The incident register includes events where the consent holder concerned has itself notified the Council. The register contains details of any investigation and corrective action taken.

Complaints may be alleged to be associated with a particular site. If there is potentially an issue of legal liability, the Council must be able to prove by investigation that the identified company is indeed the source of the incident (or that the allegation cannot be proven).

During the period under review, the Council was not required to undertake significant additional investigations and interventions, or record incidents, in association with GPL's conditions in resource consents or provisions in Regional Plans.

3 Discussion

3.1 Environmental effects of exercise of consents

One well (Kowhai-5) was stimulated by hydraulic fracturing at the Kowhai-D wellsite during the period 22 January 2019 to 11 March 2019.

The monitoring programme carried out by the Council in relation to the fracturing events undertaken included both groundwater and surface water monitoring components.

The groundwater monitoring component incorporated pre and post-fracturing sampling at one groundwater monitoring site located just outside the perimeter of the Kowhai-D wellsite. The results of post-fracturing groundwater sampling carried out showed only very minor variations in water composition in comparison to baseline results. The minor variations in analytes are a result of natural variations in water composition.

The surface water monitoring component of the programme comprised of one biomonitoring survey of an unnamed tributary of the Waitara River pre-fracturing of the Kowhai-5 well. Due to unsuitable sampling conditions following the event, post-fracturing biomonitoring was not undertaken. Previous surveys at the wellsite have found no discernible impacts on the macroinvertebrate community, attributable to the activity.

In summary, the monitoring carried out by the Council during the period being reported indicated that the hydraulic fracturing activities undertaken by GPL at the Kowhai-D wellsite has had no significant adverse effects on local groundwater or surface water resources.

3.2 Evaluation of performance

A tabular summary of the consent holder's compliance record for the year under review is set out in Table 8.

Table 8 Summary of performance for consent 10297-1

| Purpose: To discharge water based hydraulic fracturing fluids into land at depths greater than 3,385 m TVDss beneath the Kowhai-D wellsite | | |
|--|---|----------------------|
| Condition requirement | Means of monitoring during period under review | Compliance achieved? |
| 1. Any discharge shall occur below 3,385 m TVDss | Assessment of consent holder submitted data | Yes |
| 2. No discharge shall occur after 1 June 2028 | Assessment of consent holder submitted data | N/A |
| 3. Seismic monitoring requirement | Notification received | N/A |
| 4. Investigation and reporting requirements if an event occurs under condition 3 | Report received | N/A |
| 5. Exercise of consent shall not result in any contaminants reaching any useable freshwater | Results of groundwater monitoring | Yes |
| 6. Consent holder shall undertake sampling programme | Development and certification of a monitoring programme | Yes |
| 7. Monitoring programme to include a minimum of one suitable bore | Consultation and installation of monitoring bore | Yes |

Purpose: To discharge water based hydraulic fracturing fluids into land at depths greater than 3,385 m TVDss beneath the Kowhai-D wellsite

| Condition requirement | Means of monitoring during period under review | Compliance achieved? |
|---|---|----------------------|
| 8. Sampling programme shall follow recognised field procedures and be analysed for a specified range of chemical parameters | Development and certification of a monitoring programme and assessment of results | Yes |
| 9. All sampling to be carried out in accordance with a certified Sampling and Analysis Plan | Development and certification of a Sampling and Analysis Plan | Yes |
| 10. Well and equipment pressure testing to be carried out prior to any hydraulic fracturing programme commencing | Assessment of consent holder submitted data | Yes |
| 11. A pre-fracturing discharge report is to be provided to the Council 14 days prior to discharge | Pre-fracturing discharge report received | Yes |
| 12. Consent holder shall notify the Council of hydraulic fracturing discharge | Notification received | Yes |
| 13. A post-fracturing discharge report is to be provided to the Council within 90 days of any commencement | Post-fracturing discharge report received | Yes |
| 14. An interim post-fracturing discharge report is to be provided in order to meet the 90 day requirement if the consent holder cannot provide all the information required by condition 13 | Interim post-fracturing report received | Yes |
| 15. The reports outlined in conditions 11 and 13 must be emailed to consents@trc.govt.nz | Reports received via email | Yes |
| 16. The consent holder shall provide access to a location where samples of hydraulic fracturing fluids and return fluids can be obtained by the Council officers | Access provided | Yes |
| 17. Consent holder to adopt best practicable option at all times | Site inspections, sampling and assessment of consent holder submitted data | Yes |
| 18. Fracture fluid composition no less than 95 % water and proppant by volume | Assessment of consent holder submitted data and sampling of fracturing fluid | Yes |
| 19. Lapse clause | Receive notice of exercise of consent | Yes |
| 20. Notice of Council to review consent | No provision for review during period | N/A |

| Purpose: To discharge water based hydraulic fracturing fluids into land at depths greater than 3,385 m TVDss beneath the Kowhai-D wellsite | | |
|--|--|----------------------|
| Condition requirement | Means of monitoring during period under review | Compliance achieved? |
| Overall assessment of environmental performance and compliance in respect of this consent | | High |
| Overall assessment of administrative performance and compliance in respect of this consent | | High |

N/A = not applicable

During the year, GPL demonstrated a high level of environmental and high level of administrative performance with the resource consent as defined in Section 1.1.4.

3.3 Alterations to monitoring programmes of future hydraulic fracturing events

In designing and implementing the monitoring programmes for air/water discharges in the region, the Council has taken into account:

- the extent of information already made available through monitoring or other means to date;
- its relevance under the RMA;
- the Council's obligations to monitor consented activities and their effects under the RMA;
- the record of administrative and environmental performances of the consent holder; and
- reporting to the regional community.

The Council also takes into account the scope of assessments required at the time of renewal of permits, and the need to maintain a sound understanding of industrial processes within Taranaki exercising resource consents.

It is proposed that the range of monitoring carried out in relation to the hydraulic fracturing activities undertaken by GPL be replicated for any future fracturing events at the Kowhai-D wellsite.

Recommendations to this effect are included in Section 4 of this report.

It should be noted that the proposed programme represents a reasonable and risk-based level of monitoring for the site in question. The Council reserves the right to subsequently adjust the programme from that initially prepared, should the need arise if potential or actual non-compliance is determined at any time during future monitoring periods.

3.4 Exercise of optional review of consent

Resource consent 10297-1 provides for an optional review of the consent in June 2021. Condition 20 allows the Council to review the consent, for the purpose of:

- a. ensuring that the conditions are adequate to deal with any significant adverse effects on the environment arising from the exercise of this consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or
- b. further specifying the best practicable option as required by condition 17; and/or
- c. ensuring hydraulic fracturing operations appropriately take into account any best practice guidance published by a recognised industry association or environmental regulator.

Based on the results of monitoring in the year under review, it is considered that there are no grounds that require a review to be pursued or grounds to exercise the review option.

4 Recommendations

1. THAT in the first instance, the range of monitoring carried out during the reporting period in relation to GPL's hydraulic fracturing activities be replicated for any future fracturing events at the Kowhai-D wellsite.
2. THAT should there be issues with environmental or administrative performance in future periods, monitoring may be adjusted to reflect any additional investigation or intervention as found necessary.
3. THAT the option for a review of resource consents in June 2021, as set out in condition 20 of the consent not be exercised.

Glossary of common terms and abbreviations

The following abbreviations and terms may be used within this report:

| | |
|-----------------------|---|
| Biomonitoring | Assessing the health of the environment using aquatic organisms. |
| bbls | Barrel. Unit of measure used in the oil and gas industry (equivalent to approximately 159 litres). |
| Conductivity | Conductivity, an indication of the level of dissolved salts in a sample, usually measured at 25°C and expressed in $\mu\text{S}/\text{cm}$. |
| DO | Dissolved oxygen. |
| <i>E.coli</i> | Escherichia coli, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample. |
| EPT | Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) which are macroinvertebrates sensitive to pollution. |
| Fresh | Elevated flow in a stream, such as after heavy rainfall. |
| g/m^3 | Grams per cubic metre, and equivalent to milligrams per litre (mg/L). In water, this is also equivalent to parts per million (ppm), but the same does not apply to gaseous mixtures. |
| Incident | An event that is alleged or is found to have occurred that may have actual or potential environmental consequences or may involve non-compliance with a consent or rule in a regional plan. Registration of an incident by the Council does not automatically mean such an outcome had actually occurred. |
| Intervention | Action/s taken by Council to instruct or direct actions be taken to avoid or reduce the likelihood of an incident occurring. |
| Investigation | Action taken by Council to establish the circumstances/events surrounding an incident including any allegations of an incident. |
| L/s | Litres per second. |
| Macroinvertebrate | An invertebrate that is large enough to be seen without the use of a microscope. |
| masl | Metres above sea level. |
| MCI | Macroinvertebrate community index; a numerical indication of the state of biological life in a stream that takes into account the sensitivity of the taxa present to organic pollution in stony habitats. |
| mS/m | Millisiemens per metre. |
| m^3 | Cubic metre (1,000 litres). |
| NZTM | New Zealand Transverse Mercator coordinates. |
| pH | A numerical system for measuring acidity in solutions, with 7 as neutral. Numbers lower than 7 are increasingly acidic and higher than 7 are increasingly alkaline. |
| Physicochemical | Measurement of both physical properties (e.g. temperature, clarity, density) and chemical determinants (e.g. metals and nutrients) to characterise the state of an environment. |
| Resource consent | Refer Section 87 of the RMA. Resource consents include land use consents (refer Sections 9 and 13 of the RMA), coastal permits (Sections 12, 14 and 15), water permits (Section 14) and discharge permits (Section 15). |
| RMA | Resource Management Act 1991 and including all subsequent amendments. |

| | |
|------------------|---|
| Screen Out | A condition that occurs when the solids carried in a treatment fluid, such as proppant in a fracture fluid, create a bridge across the perforations or similar restricted flow area. This creates a sudden and significant restriction to fluid flow that causes a rapid rise in pump pressure. |
| SQMCI | Semi quantitative macroinvertebrate community index. |
| TVDss | True vertical depth sub-sea. |
| $\mu\text{S/cm}$ | Microsiemens per centimetre. |
| Workover | The repair or stimulation of an existing production well for the purpose of restoring, prolonging or enhancing the production of hydrocarbons. |

For further information on analytical methods, contact a Science Services Manager.

Bibliography and references

- Baker Hughes at <http://blogs.bakerhughes.com/reservoir/2012/02/20/hydraulic-fracturing-an-environmentally-responsible-technology-for-ensuring-our-energy-future-part-iii-of-iii>
- Geology.Com at <http://geology.com/energy/hydraulic-fracturing-fluids/>
- TRC (2020) Biomonitoring of an unnamed tributary of the Waitara River in relation to hydrocarbon exploration at the Kowhai-D wellsite, November 2018 #2437453.
- Greymouth Petroleum Ltd (2018) Hydraulic fracturing -Kowhai-D wellsite water quality monitoring programme April 2018 Frodo Number #1756912.
- Greymouth Petroleum Ltd (2020) Kowhai-5 post-stimulation discharge report June 2020 Frodo Number #2514563.
- Greymouth Petroleum Ltd (2019) Kowhai-5 post-stimulation discharge report May 2019 Frodo Number #2254726.
- Greymouth Petroleum Ltd (2018) Kowhai-5 pre-fracturing report August 2018 Frodo Number #2254767.
- Ministry for the Environment. 2018 Guidelines for compliance monitoring and enforcement under the Resource Management Act 1991. Wellington: Ministry for the Environment.
- Stark JD, (1998). SQMCI: a biotic index for freshwater macroinvertebrate coded abundance data. New Zealand Journal of Marine and Freshwater Research 32(1): 55-66.

Appendix I

Resource consent held by Greymouth Petroleum Mining Group Ltd

(For a copy of the signed resource consent
please contact the TRC Consents department)

Water abstraction permits

Section 14 of the RMA stipulates that no person may take, use, dam or divert any water, unless the activity is expressly allowed for by a resource consent or a rule in a regional plan, or it falls within some particular categories set out in Section 14. Permits authorising the abstraction of water are issued by the Council under Section 87(d) of the RMA.

Water discharge permits

Section 15(1)(a) of the RMA stipulates that no person may discharge any contaminant into water, unless the activity is expressly allowed for by a resource consent or a rule in a regional plan, or by national regulations. Permits authorising discharges to water are issued by the Council under Section 87(e) of the RMA.

Air discharge permits

Section 15(1)(c) of the RMA stipulates that no person may discharge any contaminant from any industrial or trade premises into air, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations. Permits authorising discharges to air are issued by the Council under Section 87(e) of the RMA.

Discharges of wastes to land

Sections 15(1)(b) and (d) of the RMA stipulate that no person may discharge any contaminant onto land if it may then enter water, or from any industrial or trade premises onto land under any circumstances, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations. Permits authorising the discharge of wastes to land are issued by the Council under Section 87(e) of the RMA.

Land use permits

Section 13(1)(a) of the RMA stipulates that no person may in relation to the bed of any lake or river use, erect, reconstruct, place, alter, extend, remove, or demolish any structure or part of any structure in, on, under, or over the bed, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations. Land use permits are issued by the Council under Section 87(a) of the RMA.

Coastal permits

Section 12(1)(b) of the RMA stipulates that no person may erect, reconstruct, place, alter, extend, remove, or demolish any structure that is fixed in, on, under, or over any foreshore or seabed, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations. Coastal permits are issued by the Council under Section 87(c) of the RMA.

Discharge Permit
Pursuant to the Resource Management Act 1991
a resource consent is hereby granted by the
Taranaki Regional Council

Name of
Consent Holder: Petrochem Limited
PO Box 3394
New Plymouth 4341

Decision Date: 24 May 2016

Commencement Date: 24 May 2016

Conditions of Consent

Consent Granted: To discharge water based hydraulic fracturing fluids into land at depths greater than 3,385 mTVDss beneath the Kowhai-D wellsite

Expiry Date: 1 June 2033

Review Date(s): June Annually and in accordance with special condition 20

Site Location: Kowhai-D wellsite, 17 Manganui Road, Everett Park
(Property owner: Clonakillity Farms Limited)

Grid Reference (NZTM) 1710128E-5674886N

Catchment: Waitara

*For General, Standard and Special conditions
pertaining to this consent please see reverse side of this document*

General condition

- a. The consent holder shall pay to the Taranaki Regional Council all the administration, monitoring and supervision costs of this consent, fixed in accordance with section 36 of the Resource Management Act 1991.

Special conditions

1. The discharge point shall be deeper than 3,385 mTVDss.

Note: mTVDss = metres true vertical depth subsea, i.e., the true vertical depth in metres below mean sea level
2. There shall be no discharge of hydraulic fracturing fluids after 1 June 2028.
3. If the GeoNet seismic monitoring network records a seismic event higher than a Modified Mercalli intensity of magnitude 3.0 within 5 km of the geographical position (in 3 dimensions) of any hydraulic fracturing discharge, then:
 - (a) if a hydraulic fracturing discharge is currently being undertaken it shall cease immediately and not recommence; or
 - (b) if a hydraulic fracturing discharge has occurred within the previous 72 hours no further hydraulic fracturing discharges shall occur.
4. Following the occurrence of any seismic event described in special condition 3 the consent holder shall investigate and report to the Chief Executive, Taranaki Regional Council on the likelihood of the seismic event being induced by the exercise of this consent. Hydraulic fracturing discharges may only then continue once the Chief Executive, Taranaki Regional Council has considered the report and concluded that the environmental risk of recommencing hydraulic fracturing is acceptable and has advised the consent holder accordingly.
5. The consent holder shall ensure that the exercise of this consent does not result in contaminants reaching any useable fresh water (groundwater or surface water). Usable fresh groundwater is defined as any groundwater having a Total Dissolved Solids concentration of less than 1,000 mg/l.
6. The consent holder shall undertake a programme of sampling and testing that monitors the effects of the exercise of this consent on fresh water resources to assess compliance with condition 5 (the 'Monitoring Programme'). The Monitoring Programme shall be certified by the Chief Executive, Taranaki Regional Council ('the Chief Executive'), before this consent is exercised, and shall include:
 - (a) the location of the discharge point(s);
 - (b) the location of sampling sites; and
 - (c) sampling frequency with reference to a hydraulic fracturing programme.

7. Depending on the suitability of existing bores within 500 metres of the wellsite for obtaining a representative groundwater sample, it may be necessary for the Monitoring Programme to include installation of, and sampling from, at least one monitoring bore. The bore(s) would be of a depth, location and design determined after consultation with the Chief Executive, Taranaki Regional Council and installed in accordance with NZS 4411:2001.
8. All water samples taken for monitoring purposes shall be taken in accordance with recognised field procedures and analysed for:
 - (a) pH;
 - (b) conductivity;
 - (c) total dissolved solids;
 - (d) major ions (Ca, Mg, K, Na, total alkalinity, bromide, chloride, nitrate-nitrogen, and sulphate);
 - (e) trace metals (barium, copper, iron, manganese, nickel, and zinc);
 - (f) total petroleum hydrocarbons;
 - (g) formaldehyde;
 - (h) dissolved methane and ethane gas;
 - (i) methanol;
 - (j) glycols;
 - (k) benzene, toluene, ethylbenzene, and xylenes (BTEX); and
 - (l) carbon-13 composition of any dissolved methane gas discovered ($^{13}\text{C-CH}_4$).

Note: The samples required, under conditions of this consent could be taken and analysed by the Taranaki Regional Council or other contracted party on behalf of the consent holder.

9. All sampling and analysis shall be undertaken in accordance with a *Sampling and Analysis Plan*, which shall be submitted to the Chief Executive for review and certification before the first sampling is undertaken. The plan shall specify the use of standard protocols recognised to constitute good professional practice including quality control and assurance. An International Accreditation New Zealand (IANZ) accredited laboratory shall be used for all sample analysis. Results shall be provided to the Chief Executive within 30 days of sampling and shall include supporting quality control and assurance information. These results will be used to assess compliance with condition 5.

Note: The Sampling and Analysis Plan may be combined with the Monitoring Programme required by condition 6.

10. The consent holder shall undertake well and equipment pressure testing prior to any hydraulic fracture programme on a given well to ensure any discharge will not affect the integrity of the well and hydraulic fracturing equipment.

11. Any hydraulic fracture discharge shall only occur after the consent holder has provided a comprehensive 'Pre-fracturing Discharge Report' to the Chief Executive. The report shall be provided at least 14 days before the discharge is proposed to commence and shall detail the hydraulic fracturing programme proposed, including as a minimum:
- (a) the specific well in which each discharge is to occur, the intended fracture interval(s) ('fracture interval' is the discrete subsurface zone to receive a hydraulic fracture treatment), and the duration of the hydraulic fracturing programme;
 - (b) the number of discharges proposed and the geographical position (i.e. depth and lateral position) of each intended discharge point;
 - (c) the total volume of fracture fluid planned to be pumped down the well, including mini-fracture treatments, and their intended composition, including a list of all contaminants and Material Safety Data Sheets for all the chemicals to be used;
 - (d) the monitoring techniques to be used to determine the fate of discharged material;
 - (e) the results of the reviews required by condition 17;
 - (f) results of modelling showing an assessment of the likely extent and dimensions of the fractures that will be generated by the discharge;
 - (g) the preventative and mitigation measures to be in place to ensure the discharge does not cause adverse environmental effects and complies with condition 5;
 - (h) the extent and permeability characteristics of the geology above the discharge point to the surface;
 - (i) any identified faults within the modelled fracture length plus a margin of 50%, and the potential for adverse environmental effects due to the presence of the identified faults;
 - (j) the burst pressure of the well casing and the anticipated maximum well and discharge pressures and the duration of the pressures; and
 - (k) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal; and
 - (l) details why the contaminants in the discharge and the monitoring techniques used comply with condition 17.

Note: For the avoidance of doubt, the information provided with a resource consent application would usually be sufficient to constitute a 'Pre-fracturing Discharge Report' for any imminent hydraulic fracturing discharge. The Pre-fracturing Discharge Report provided for any later discharge may refer to the resource consent application or earlier Pre-fracturing Discharge Reports noting any differences.

12. The consent holder shall notify the Taranaki Regional Council of the date that each discharge is intended to commence by emailing worknotification@trc.govt.nz. Notification also shall identify the 'Pre-fracturing Discharge Report', required by condition 11, which details the discharge and be given no less than 3 days before the intended discharge date. If any discharge occurs more than 30 days after the notification date, additional notification as specified in this condition is required.

Consent 10297-1.0

13. Subject to condition 14, within 90 days of any commencement date as advised under condition 12, the consent holder shall submit a comprehensive 'Post-fracturing Discharge Report' to the Chief Executive. The report shall, as a minimum, contain:
 - (a) date and time of discharge;
 - (b) confirmation of the interval(s) where fracturing occurred for that programme, and the geographical position (i.e., depth and lateral position) of the discharge point for each fracture interval;
 - (c) the contaminant volumes and composition of fluid discharged into each fracture interval;
 - (d) the volume of return fluids from each fracture interval;
 - (e) an analysis for the constituents set out in conditions 8(a) to 8(k), in a return fluid sample taken within the first two hours of flow back, for each fracture interval if flowed back individually, or for the well if flowed back with all intervals comingled;
 - (f) an estimate of the volume of fluids (and proppant) remaining underground;
 - (g) the volume of water produced with the hydrocarbons (produced water) over the period beginning at the start of the hydraulic fracturing programme and ending 30 days after the programme is completed or after that period of production;
 - (h) an assessment of the extent and dimensions of the fractures that were generated by the discharge, based on modelling undertaken after the discharge has occurred and other diagnostic techniques, including production analysis, available to determine fracture length, height and containment;
 - (i) the results of pressure testing required by condition 10 and the top-hole pressure (psi), slurry rate (bpm), surface proppant concentration (lb/gal), bottom hole proppant concentration (lb/gal), and calculated bottom hole pressure (psi), as well as predicted values for each of these parameters; prior to, during and after each hydraulic fracture treatment;
 - (j) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal;
 - (k) details of any incidents where hydraulic fracture fluid is unable to pass through the well perforations (screen outs) that occurred, their likely cause and implications for compliance with conditions 1 and 5; and
 - (l) results of the monitoring referred to in condition 11 (d); and
 - (m) an assessment of the effectiveness of the mitigation measures in place with specific reference to those described in the application for this consent.
14. On occasions, including for programs involving multiple hydraulic fracturing discharges, more than one 'Post-fracturing discharge report' may be required in order to meet the 90-day deadline from commencement required by condition 13. In these situations the consent holder shall submit an 'Interim Post-fracturing Discharge Report', which includes all the information that is available, to the Chief Executive within 90 days and a final Post-fracturing report as soon as practicable but within 90 days of the interim report.
15. The reports described in conditions 11 and 13 shall be emailed to consents@trc.govt.nz with a reference to the number of this consent.
16. The consent holder shall provide access to a location where the Taranaki Regional Council officers can obtain a sample of the hydraulic fracturing fluids and the return fluids.

Consent 10297-1.0

17. The consent holder shall at all times adopt the best practicable option, as defined in section 2 of the Resource Management Act 1991, to prevent or minimize any actual or likely adverse effect of the activity on the environment by, as a minimum, ensuring that:
 - (a) the discharge is contained within the fracture interval;
 - (b) regular reviews of monitoring techniques used to ensure the discharge does not cause adverse environmental effects are undertaken;
 - (c) regular reviews are undertaken of the preventative and mitigation measures adopted to ensure the discharge does not cause adverse environmental effects; and
 - (d) regular reviews of the chemicals used are undertaken with a view to reducing the toxicity of the chemicals used.
18. The fracture fluid shall be comprised of no less than 95% water and proppant by volume.
19. This consent shall lapse on 30 June 2021, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(1)(b) of the Resource Management Act 1991.
20. The Taranaki Regional Council may review any or all of the conditions of this consent by giving notice of review:
 - a) during the month of June each year, and/or
 - b) within 30 days of receiving any investigation and report in accordance with condition 4 above;for the purposes of:
 - (a) ensuring that the conditions are adequate to deal with any significant adverse effects on the environment arising from the exercise of this consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or
 - (b) further specifying the best practicable option as required by condition 17; and/or
 - (c) ensuring hydraulic fracturing operations appropriately take into account any best practice guidance published by a recognised industry association or environmental regulator.

Signed at Stratford on 24 May 2016

For and on behalf of
Taranaki Regional Council

B G Chamberlain
Chief Executive

Appendix II

Certificates of analysis (groundwater)



Certificate of Analysis

| | | | | |
|-----------------|---|--------------------------|--------------------------|------|
| Client: | Taranaki Regional Council | Lab No: | 2040610 | SPV1 |
| Contact: | Jane Harvey C/- Taranaki Regional Council Private Bag 713 Stratford 4352 | Date Received: | 31-Aug-2018 | |
| | | Date Reported: | 07-Sep-2018 | |
| | | Quote No: | 47915 | |
| | | Order No: | 72831 | |
| | | Client Reference: | 340300418 Kawhai D Iyraw | |
| | | Submitted By: | Sarah Larkin | |

Sample Type: Aqueous

| | | | | | |
|---------------------|---|--|--|--|--|
| Sample Name: | GND2632 TRC183458 30-Aug-2018 12:15 pm | | | | |
| Lab Number: | 2040610.1 | | | | |

Individual Tests

| | | | | | | |
|--------------------------------------|---------------------------------------|-----------|---|---|---|---|
| Sum of Anions | meq/L | 3.3 | - | - | - | - |
| Sum of Cations | meq/L | 3.2 | - | - | - | - |
| pH | pH Units | 8.2 | - | - | - | - |
| Total Alkalinity | g/m ³ as CaCO ₃ | 148 | - | - | - | - |
| Bicarbonate | g/m ³ at 25°C | 178 | - | - | - | - |
| Total Hardness | g/m ³ as CaCO ₃ | 84 | - | - | - | - |
| Electrical Conductivity (EC) | mS/m | 31.3 | - | - | - | - |
| Total Dissolved Solids (TDS) | g/m ³ | 180 | - | - | - | - |
| Sample Temperature* | °C | 14.8 | - | - | - | - |
| Dissolved Barium | g/m ³ | 0.006 | - | - | - | - |
| Dissolved Calcium | g/m ³ | 19.4 | - | - | - | - |
| Dissolved Copper | g/m ³ | < 0.0005 | - | - | - | - |
| Dissolved Iron | g/m ³ | 0.04 | - | - | - | - |
| Dissolved Magnesium | g/m ³ | 8.7 | - | - | - | - |
| Dissolved Manganese | g/m ³ | 0.0091 | - | - | - | - |
| Dissolved Mercury | g/m ³ | < 0.00008 | - | - | - | - |
| Dissolved Nickel | g/m ³ | < 0.0005 | - | - | - | - |
| Dissolved Potassium | g/m ³ | 3.1 | - | - | - | - |
| Dissolved Sodium | g/m ³ | 33 | - | - | - | - |
| Dissolved Zinc | g/m ³ | < 0.0010 | - | - | - | - |
| Bromide | g/m ³ | 0.07 | - | - | - | - |
| Chloride | g/m ³ | 12.0 | - | - | - | - |
| Nitrite-N | g/m ³ | < 0.002 | - | - | - | - |
| Nitrate-N | g/m ³ | < 0.002 | - | - | - | - |
| Nitrate-N + Nitrite-N | g/m ³ | < 0.002 | - | - | - | - |
| Sulphate | g/m ³ | < 0.5 | - | - | - | - |
| Ethylene Glycol in Water | | | | | | |
| Ethylene glycol* | g/m ³ | < 4 | - | - | - | - |
| Propylene Glycol in Water | | | | | | |
| Propylene glycol* | g/m ³ | < 4 | - | - | - | - |
| Methanol in Water - Aqueous Solvents | | | | | | |
| Methanol* | g/m ³ | < 2 | - | - | - | - |



| Sample Type: Aqueous | | | | | | |
|--|---|----------|---|---|---|---|
| Sample Name: | GND2632 TRC183458 30-Aug-2018 12:15 pm | | | | | |
| Lab Number: | 2040610.1 | | | | | |
| BTEX in Water by Headspace GC-MS | | | | | | |
| Benzene | g/m ³ | < 0.0010 | - | - | - | - |
| Toluene | g/m ³ | < 0.0010 | - | - | - | - |
| Ethylbenzene | g/m ³ | < 0.0010 | - | - | - | - |
| m&p-Xylene | g/m ³ | < 0.002 | - | - | - | - |
| o-Xylene | g/m ³ | < 0.0010 | - | - | - | - |
| Formaldehyde in Water by DNPH & LCMSMS | | | | | | |
| Formaldehyde | g/m ³ | < 0.02 | - | - | - | - |
| Gases in groundwater | | | | | | |
| Ethane | g/m ³ | 0.008 | - | - | - | - |
| Ethylene | g/m ³ | < 0.004 | - | - | - | - |
| Methane | g/m ³ | 8.6 | - | - | - | - |
| Total Petroleum Hydrocarbons in Water | | | | | | |
| C7 - C9 | g/m ³ | < 0.06 | - | - | - | - |
| C10 - C14 | g/m ³ | < 0.2 | - | - | - | - |
| C15 - C36 | g/m ³ | < 0.4 | - | - | - | - |
| Total hydrocarbons (C7 - C36) | g/m ³ | < 0.7 | - | - | - | - |

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

| Sample Type: Aqueous | | | |
|--|--|---|-----------|
| Test | Method Description | Default Detection Limit | Sample No |
| Ethylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 1 |
| Propylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 1 |
| Methanol in Water - Aqueous Solvents* | Direct injection, dual column GC-FID | 1.0 g/m ³ | 1 |
| BTEX in Water by Headspace GC-MS | Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] | 0.0010 - 0.002 g/m ³ | 1 |
| Formaldehyde in Water by DNPH & LCMSMS | DNPH derivatisation, extraction, LCMSMS | 0.02 g/m ³ | 1 |
| Gases in groundwater | Manual headspace creation and sub-sampling, GC-FID analysis. | 0.002 - 0.003 g/m ³ | 1 |
| Total Petroleum Hydrocarbons in Water | Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] | 0.06 - 0.7 g/m ³ | 1 |
| Filtration, Unpreserved | Sample filtration through 0.45µm membrane filter. | - | 1 |
| Total anions for anion/cation balance check | Calculation: sum of anions as mEq/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22 nd ed. 2012. | 0.07 meq/L | 1 |
| Total cations for anion/cation balance check | Sum of cations as mEq/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H ⁺) also included in calculation if available. APHA 1030 E 22 nd ed. 2012. | 0.05 meq/L | 1 |
| pH | pH meter. APHA 4500-H ⁺ B 22 nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used. | 0.1 pH Units | 1 |
| Total Alkalinity | Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22 nd ed. 2012. | 1.0 g/m ³ as CaCO ₃ | 1 |
| Bicarbonate | Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO ₂ D 22 nd ed. 2012. | 1.0 g/m ³ at 25°C | 1 |
| Total Hardness | Calculation from Calcium and Magnesium. APHA 2340 B 22 nd ed. 2012. | 1.0 g/m ³ as CaCO ₃ | 1 |

| Sample Type: Aqueous | | | |
|------------------------------|--|--------------------------|-----------|
| Test | Method Description | Default Detection Limit | Sample No |
| Electrical Conductivity (EC) | Conductivity meter, 25°C. APHA 2510 B 22 nd ed. 2012. | 0.1 mS/m | 1 |
| Total Dissolved Solids (TDS) | Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22 nd ed. 2012. | 10 g/m ³ | 1 |
| Sample Temperature* | Supplied by customer, otherwise 20°C. | 0.1 °C | 1 |
| Dissolved Barium | Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012. | 0.005 g/m ³ | 1 |
| Dissolved Calcium | Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012. | 0.05 g/m ³ | 1 |
| Dissolved Copper | Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012. | 0.0005 g/m ³ | 1 |
| Dissolved Iron | Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012. | 0.02 g/m ³ | 1 |
| Dissolved Magnesium | Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012. | 0.02 g/m ³ | 1 |
| Dissolved Manganese | Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012. | 0.0005 g/m ³ | 1 |
| Dissolved Mercury | 0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005. | 0.00008 g/m ³ | 1 |
| Dissolved Nickel | Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012. | 0.0005 g/m ³ | 1 |
| Dissolved Potassium | Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012. | 0.05 g/m ³ | 1 |
| Dissolved Sodium | Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012. | 0.02 g/m ³ | 1 |
| Dissolved Zinc | Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012. | 0.0010 g/m ³ | 1 |
| Bromide | Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22 nd ed. 2012. | 0.05 g/m ³ | 1 |
| Chloride | Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22 nd ed. 2012. | 0.5 g/m ³ | 1 |
| Nitrite-N | Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₂ ⁻ I 22 nd ed. 2012 (modified). | 0.002 g/m ³ | 1 |
| Nitrate-N | Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N. In-House. | 0.0010 g/m ³ | 1 |
| Nitrate-N + Nitrite-N | Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO ₃ ⁻ I 22 nd ed. 2012 (modified). | 0.002 g/m ³ | 1 |
| Sulphate | Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22 nd ed. 2012. | 0.5 g/m ³ | 1 |
| C7 - C9 | Head Space, GCMS analysis. | 0.06 g/m ³ | 1 |

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental



Certificate of Analysis

Page 1 of 3

| | | | | |
|-----------------|---|--------------------------|--|------|
| Client: | Taranaki Regional Council | Lab No: | 2226769 | SPV1 |
| Contact: | Jane Harvey C/- Taranaki Regional Council Private Bag 713 Stratford 4352 | Date Received: | 20-Aug-2019 | |
| | | Date Reported: | 27-Aug-2019 | |
| | | Quote No: | 47915 | |
| | | Order No: | 72831 | |
| | | Client Reference: | #5215 - Kowhai D 1 yr Post Frac GW/Interim | |
| | | Submitted By: | Sarah Larkin | |

Sample Type: Aqueous

| | | | | | |
|---------------------|---|--|--|--|--|
| Sample Name: | TRC192969 (GND2632) 19-Aug-2019 12:10 pm | | | | |
| Lab Number: | 2226769.1 | | | | |

Individual Tests

| | | | | | | |
|--------------------------------------|---------------------------------------|-----------|---|---|---|---|
| Sum of Anions | meq/L | 3.3 | - | - | - | - |
| Sum of Cations | meq/L | 3.2 | - | - | - | - |
| pH | pH Units | 8.2 | - | - | - | - |
| Total Alkalinity | g/m ³ as CaCO ₃ | 150 | - | - | - | - |
| Bicarbonate | g/m ³ at 25°C | 180 | - | - | - | - |
| Total Hardness | g/m ³ as CaCO ₃ | 84 | - | - | - | - |
| Electrical Conductivity (EC) | mS/m | 31.8 | - | - | - | - |
| Total Dissolved Solids (TDS) | g/m ³ | 169 | - | - | - | - |
| Sample Temperature* | °C | 13.9 | - | - | - | - |
| Dissolved Barium | g/m ³ | 0.005 | - | - | - | - |
| Dissolved Calcium | g/m ³ | 21 | - | - | - | - |
| Dissolved Copper | g/m ³ | < 0.0005 | - | - | - | - |
| Dissolved Iron | g/m ³ | 0.04 | - | - | - | - |
| Dissolved Magnesium | g/m ³ | 8.0 | - | - | - | - |
| Dissolved Manganese | g/m ³ | 0.0091 | - | - | - | - |
| Dissolved Mercury | g/m ³ | < 0.00008 | - | - | - | - |
| Dissolved Nickel | g/m ³ | < 0.0005 | - | - | - | - |
| Dissolved Potassium | g/m ³ | 3.0 | - | - | - | - |
| Dissolved Sodium | g/m ³ | 33 | - | - | - | - |
| Dissolved Zinc | g/m ³ | 0.0083 | - | - | - | - |
| Bromide | g/m ³ | 0.07 | - | - | - | - |
| Chloride | g/m ³ | 11.7 | - | - | - | - |
| Nitrite-N | g/m ³ | < 0.002 | - | - | - | - |
| Nitrate-N | g/m ³ | < 0.002 | - | - | - | - |
| Nitrate-N + Nitrite-N | g/m ³ | < 0.002 | - | - | - | - |
| Sulphate | g/m ³ | < 0.5 | - | - | - | - |
| Ethylene Glycol in Water | | | | | | |
| Ethylene glycol* | g/m ³ | < 4 | - | - | - | - |
| Propylene Glycol in Water | | | | | | |
| Propylene glycol* | g/m ³ | < 4 | - | - | - | - |
| Methanol in Water - Aqueous Solvents | | | | | | |
| Methanol* | g/m ³ | < 2 | - | - | - | - |



| Sample Type: Aqueous | | | | | | |
|--|---|----------|---|---|---|---|
| Sample Name: | TRC192969 (GND2632) 19-Aug-2019 12:10 pm | | | | | |
| Lab Number: | 2226769.1 | | | | | |
| BTEX in Water by Headspace GC-MS | | | | | | |
| Benzene | g/m ³ | < 0.0010 | - | - | - | - |
| Toluene | g/m ³ | < 0.0010 | - | - | - | - |
| Ethylbenzene | g/m ³ | < 0.0010 | - | - | - | - |
| m&p-Xylene | g/m ³ | < 0.002 | - | - | - | - |
| o-Xylene | g/m ³ | < 0.0010 | - | - | - | - |
| Formaldehyde in Water by DNPH & LCMSMS | | | | | | |
| Formaldehyde | g/m ³ | < 0.02 | - | - | - | - |
| Gases in groundwater | | | | | | |
| Ethane | g/m ³ | 0.008 | - | - | - | - |
| Ethylene | g/m ³ | < 0.004 | - | - | - | - |
| Methane | g/m ³ | 9.9 | - | - | - | - |
| Total Petroleum Hydrocarbons in Water | | | | | | |
| C7 - C9 | g/m ³ | < 0.06 | - | - | - | - |
| C10 - C14 | g/m ³ | < 0.2 | - | - | - | - |
| C15 - C36 | g/m ³ | < 0.4 | - | - | - | - |
| Total hydrocarbons (C7 - C36) | g/m ³ | < 0.7 | - | - | - | - |

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

| Sample Type: Aqueous | | | |
|--|--|---|-----------|
| Test | Method Description | Default Detection Limit | Sample No |
| Ethylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 1 |
| Propylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 1 |
| Methanol in Water - Aqueous Solvents* | Direct injection, dual column GC-FID | 1.0 g/m ³ | 1 |
| BTEX in Water by Headspace GC-MS | Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] | 0.0010 - 0.002 g/m ³ | 1 |
| Formaldehyde in Water by DNPH & LCMSMS | DNPH derivatisation, extraction, LCMSMS | 0.02 g/m ³ | 1 |
| Gases in groundwater | Manual headspace creation and sub-sampling, GC-FID analysis. | 0.002 - 0.003 g/m ³ | 1 |
| Total Petroleum Hydrocarbons in Water | Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] | 0.06 - 0.7 g/m ³ | 1 |
| Filtration, Unpreserved | Sample filtration through 0.45µm membrane filter. | - | 1 |
| Total anions for anion/cation balance check | Calculation: sum of anions as mEq/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N, Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 23 rd ed. 2017. | 0.07 meq/L | 1 |
| Total cations for anion/cation balance check | Sum of cations as mEq/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H ⁺) also included in calculation if available. APHA 1030 E 23 rd ed. 2017. | 0.05 meq/L | 1 |
| pH | pH meter. APHA 4500-H ⁺ B 23 rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used. | 0.1 pH Units | 1 |
| Total Alkalinity | Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (modified for Alkalinity <20) 23 rd ed. 2017. | 1.0 g/m ³ as CaCO ₃ | 1 |
| Bicarbonate | Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO ₂ D 23 rd ed. 2017. | 1.0 g/m ³ at 25°C | 1 |

| Sample Type: Aqueous | | | |
|------------------------------|--|---|-----------|
| Test | Method Description | Default Detection Limit | Sample No |
| Total Hardness | Calculation from Calcium and Magnesium. APHA 2340 B 23 rd ed. 2017. | 1.0 g/m ³ as CaCO ₃ | 1 |
| Electrical Conductivity (EC) | Conductivity meter, 25°C. APHA 2510 B 23 rd ed. 2017. | 0.1 mS/m | 1 |
| Total Dissolved Solids (TDS) | Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 23 rd ed. 2017. | 10 g/m ³ | 1 |
| Sample Temperature* | Supplied by customer, otherwise 20°C. | 0.1 °C | 1 |
| Dissolved Barium | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.005 g/m ³ | 1 |
| Dissolved Calcium | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.05 g/m ³ | 1 |
| Dissolved Copper | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.0005 g/m ³ | 1 |
| Dissolved Iron | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.02 g/m ³ | 1 |
| Dissolved Magnesium | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.02 g/m ³ | 1 |
| Dissolved Manganese | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.0005 g/m ³ | 1 |
| Dissolved Mercury | 0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005. | 0.00008 g/m ³ | 1 |
| Dissolved Nickel | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.0005 g/m ³ | 1 |
| Dissolved Potassium | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.05 g/m ³ | 1 |
| Dissolved Sodium | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.02 g/m ³ | 1 |
| Dissolved Zinc | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.0010 g/m ³ | 1 |
| Bromide | Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 rd ed. 2017. | 0.05 g/m ³ | 1 |
| Chloride | Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 rd ed. 2017. | 0.5 g/m ³ | 1 |
| Nitrite-N | Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₂ ⁻ I (modified) 23 rd ed. 2017. | 0.002 g/m ³ | 1 |
| Nitrate-N | Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N. In-House. | 0.0010 g/m ³ | 1 |
| Nitrate-N + Nitrite-N | Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO ₃ ⁻ I (modified) 23 rd ed. 2017. | 0.002 g/m ³ | 1 |
| Sulphate | Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 rd ed. 2017. | 0.5 g/m ³ | 1 |
| C7 - C9 | Head Space, GCMS analysis. | 0.06 g/m ³ | 1 |

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental



Certificate of Analysis

| | | | | |
|-----------------|---|--------------------------|---------------------------------------|------|
| Client: | Taranaki Regional Council | Lab No: | 2290886 | SPV1 |
| Contact: | Jane Harvey C/- Taranaki Regional Council Private Bag 713 Stratford 4352 | Date Received: | 11-Dec-2019 | |
| | | Date Reported: | 18-Dec-2019 | |
| | | Quote No: | 47915 | |
| | | Order No: | 72831 | |
| | | Client Reference: | #5557 - Greymouth Kowhai D 1 yr PF GW | |
| | | Submitted By: | Sarah Larkin | |

Sample Type: Aqueous

| | | | | | |
|---------------------|---|--|--|--|--|
| Sample Name: | TRC194424 (GND2632) 10-Dec-2019 11:25 am | | | | |
| Lab Number: | 2290886.1 | | | | |

Individual Tests

| | | | | | | |
|--------------------------------------|---------------------------------------|-----------|---|---|---|---|
| Sum of Anions | meq/L | 3.3 | - | - | - | - |
| Sum of Cations | meq/L | 3.4 | - | - | - | - |
| pH | pH Units | 8.2 | - | - | - | - |
| Total Alkalinity | g/m ³ as CaCO ₃ | 148 | - | - | - | - |
| Bicarbonate | g/m ³ at 25°C | 177 | - | - | - | - |
| Total Hardness | g/m ³ as CaCO ₃ | 93 | - | - | - | - |
| Electrical Conductivity (EC) | mS/m | 30.6 | - | - | - | - |
| Total Dissolved Solids (TDS) | g/m ³ | 175 | - | - | - | - |
| Sample Temperature* | °C | 16.1 | - | - | - | - |
| Dissolved Barium | g/m ³ | < 0.005 | - | - | - | - |
| Dissolved Calcium | g/m ³ | 21 | - | - | - | - |
| Dissolved Copper | g/m ³ | < 0.0005 | - | - | - | - |
| Dissolved Iron | g/m ³ | 0.04 | - | - | - | - |
| Dissolved Magnesium | g/m ³ | 9.5 | - | - | - | - |
| Dissolved Manganese | g/m ³ | 0.0087 | - | - | - | - |
| Dissolved Mercury | g/m ³ | < 0.00008 | - | - | - | - |
| Dissolved Nickel | g/m ³ | < 0.0005 | - | - | - | - |
| Dissolved Potassium | g/m ³ | 3.2 | - | - | - | - |
| Dissolved Sodium | g/m ³ | 34 | - | - | - | - |
| Dissolved Zinc | g/m ³ | < 0.0010 | - | - | - | - |
| Bromide | g/m ³ | 0.06 | - | - | - | - |
| Chloride | g/m ³ | 11.8 | - | - | - | - |
| Nitrite-N | g/m ³ | < 0.002 | - | - | - | - |
| Nitrate-N | g/m ³ | < 0.002 | - | - | - | - |
| Nitrate-N + Nitrite-N | g/m ³ | < 0.002 | - | - | - | - |
| Sulphate | g/m ³ | < 0.5 | - | - | - | - |
| Ethylene Glycol in Water | | | | | | |
| Ethylene glycol* | g/m ³ | < 4 | - | - | - | - |
| Propylene Glycol in Water | | | | | | |
| Propylene glycol* | g/m ³ | < 4 | - | - | - | - |
| Methanol in Water - Aqueous Solvents | | | | | | |
| Methanol* | g/m ³ | < 2 | - | - | - | - |



| Sample Type: Aqueous | | | | | | |
|--|---|----------|---|---|---|---|
| Sample Name: | TRC194424 (GND2632) 10-Dec-2019 11:25 am | | | | | |
| Lab Number: | 2290886.1 | | | | | |
| BTEX in Water by Headspace GC-MS | | | | | | |
| Benzene | g/m ³ | < 0.0010 | - | - | - | - |
| Toluene | g/m ³ | < 0.0010 | - | - | - | - |
| Ethylbenzene | g/m ³ | < 0.0010 | - | - | - | - |
| m&p-Xylene | g/m ³ | < 0.002 | - | - | - | - |
| o-Xylene | g/m ³ | < 0.0010 | - | - | - | - |
| Formaldehyde in Water by DNPH & LCMSMS | | | | | | |
| Formaldehyde | g/m ³ | < 0.02 | - | - | - | - |
| Gases in groundwater | | | | | | |
| Ethane | g/m ³ | 0.008 | - | - | - | - |
| Ethylene | g/m ³ | < 0.004 | - | - | - | - |
| Methane | g/m ³ | 9.4 | - | - | - | - |
| Total Petroleum Hydrocarbons in Water | | | | | | |
| C7 - C9 | g/m ³ | < 0.10 | - | - | - | - |
| C10 - C14 | g/m ³ | < 0.2 | - | - | - | - |
| C15 - C36 | g/m ³ | < 0.4 | - | - | - | - |
| Total hydrocarbons (C7 - C36) | g/m ³ | < 0.7 | - | - | - | - |

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

| Sample Type: Aqueous | | | |
|--|--|---|-----------|
| Test | Method Description | Default Detection Limit | Sample No |
| Ethylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 1 |
| Propylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 1 |
| Methanol in Water - Aqueous Solvents* | Direct injection, dual column GC-FID | 1.0 g/m ³ | 1 |
| BTEX in Water by Headspace GC-MS | Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] | 0.0010 - 0.002 g/m ³ | 1 |
| Formaldehyde in Water by DNPH & LCMSMS | DNPH derivatisation, extraction, LCMSMS | 0.02 g/m ³ | 1 |
| Gases in groundwater | Manual headspace creation and sub-sampling, GC-FID analysis. | 0.002 - 0.003 g/m ³ | 1 |
| Total Petroleum Hydrocarbons in Water | Hexane extraction, GC-FID analysis US EPA 8015B / MfE Petroleum Industry Guidelines | 0.10 - 0.7 g/m ³ | 1 |
| Filtration, Unpreserved | Sample filtration through 0.45µm membrane filter. | - | 1 |
| Total anions for anion/cation balance check | Calculation: sum of anions as mEq/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 23 rd ed. 2017. | 0.07 meq/L | 1 |
| Total cations for anion/cation balance check | Sum of cations as mEq/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H ⁺) also included in calculation if available. APHA 1030 E 23 rd ed. 2017. | 0.05 meq/L | 1 |
| pH | pH meter. APHA 4500-H ⁺ B 23 rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used. | 0.1 pH Units | 1 |
| Total Alkalinity | Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (modified for Alkalinity <20) 23 rd ed. 2017. | 1.0 g/m ³ as CaCO ₃ | 1 |
| Bicarbonate | Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO ₂ D 23 rd ed. 2017. | 1.0 g/m ³ at 25°C | 1 |
| Total Hardness | Calculation from Calcium and Magnesium. APHA 2340 B 23 rd ed. 2017. | 1.0 g/m ³ as CaCO ₃ | 1 |

| Sample Type: Aqueous | | | |
|------------------------------|--|--------------------------|-----------|
| Test | Method Description | Default Detection Limit | Sample No |
| Electrical Conductivity (EC) | Conductivity meter, 25°C. APHA 2510 B 23 rd ed. 2017. | 0.1 mS/m | 1 |
| Total Dissolved Solids (TDS) | Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 23 rd ed. 2017. | 10 g/m ³ | 1 |
| Sample Temperature* | Supplied by customer, otherwise 20°C. | 0.1 °C | 1 |
| Dissolved Barium | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.005 g/m ³ | 1 |
| Dissolved Calcium | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.05 g/m ³ | 1 |
| Dissolved Copper | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.0005 g/m ³ | 1 |
| Dissolved Iron | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.02 g/m ³ | 1 |
| Dissolved Magnesium | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.02 g/m ³ | 1 |
| Dissolved Manganese | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.0005 g/m ³ | 1 |
| Dissolved Mercury | 0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005. | 0.00008 g/m ³ | 1 |
| Dissolved Nickel | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.0005 g/m ³ | 1 |
| Dissolved Potassium | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.05 g/m ³ | 1 |
| Dissolved Sodium | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.02 g/m ³ | 1 |
| Dissolved Zinc | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.0010 g/m ³ | 1 |
| Bromide | Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 rd ed. 2017. | 0.05 g/m ³ | 1 |
| Chloride | Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 rd ed. 2017. | 0.5 g/m ³ | 1 |
| Nitrite-N | Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₂ ⁻ I (modified) 23 rd ed. 2017. | 0.002 g/m ³ | 1 |
| Nitrate-N | Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N. In-House. | 0.0010 g/m ³ | 1 |
| Nitrate-N + Nitrite-N | Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO ₃ ⁻ I (modified) 23 rd ed. 2017. | 0.002 g/m ³ | 1 |
| Sulphate | Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 rd ed. 2017. | 0.5 g/m ³ | 1 |

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Dates of testing are available on request. Please contact the laboratory for more information.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.



Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental



Certificate of Analysis

| | | |
|--|--|------|
| Client: Taranaki Regional Council | Lab No: 2151988 | SPV1 |
| Contact: Jane Harvey | Date Received: 30-Mar-2019 | |
| C/- Taranaki Regional Council | Date Reported: 08-Apr-2019 | |
| Private Bag 713 | Quote No: 47915 | |
| Stratford 4352 | Order No: 72831 | |
| | Client Reference: #4978 - GPL Kowhai D 3 month HF GW March 2019 | |
| | Submitted By: Sarah Larkin | |

Sample Type: Aqueous

| | | | | | |
|---------------------|--|--|--|--|--|
| Sample Name: | TRC191620 (GND2632) 29-Mar-2019 9:15 am | | | | |
| Lab Number: | 2151988.1 | | | | |

Individual Tests

| | | | | | | |
|--------------------------------------|---------------------------------------|-----------|---|---|---|---|
| Sum of Anions | meq/L | 3.3 | - | - | - | - |
| Sum of Cations | meq/L | 3.1 | - | - | - | - |
| pH | pH Units | 8.2 | - | - | - | - |
| Total Alkalinity | g/m ³ as CaCO ₃ | 148 | - | - | - | - |
| Bicarbonate | g/m ³ at 25°C | 177 | - | - | - | - |
| Total Hardness | g/m ³ as CaCO ₃ | 83 | - | - | - | - |
| Electrical Conductivity (EC) | mS/m | 32.2 | - | - | - | - |
| Total Dissolved Solids (TDS) | g/m ³ | 182 | - | - | - | - |
| Sample Temperature* | °C | 15.8 | - | - | - | - |
| Dissolved Barium | g/m ³ | < 0.005 | - | - | - | - |
| Dissolved Calcium | g/m ³ | 20 | - | - | - | - |
| Dissolved Copper | g/m ³ | < 0.0005 | - | - | - | - |
| Dissolved Iron | g/m ³ | 0.04 | - | - | - | - |
| Dissolved Magnesium | g/m ³ | 7.9 | - | - | - | - |
| Dissolved Manganese | g/m ³ | 0.0084 | - | - | - | - |
| Dissolved Mercury | g/m ³ | < 0.00008 | - | - | - | - |
| Dissolved Nickel | g/m ³ | < 0.0005 | - | - | - | - |
| Dissolved Potassium | g/m ³ | 3.1 | - | - | - | - |
| Dissolved Sodium | g/m ³ | 32 | - | - | - | - |
| Dissolved Zinc | g/m ³ | 0.0073 | - | - | - | - |
| Bromide | g/m ³ | 0.08 | - | - | - | - |
| Chloride | g/m ³ | 11.6 | - | - | - | - |
| Nitrite-N | g/m ³ | < 0.002 | - | - | - | - |
| Nitrate-N | g/m ³ | < 0.002 | - | - | - | - |
| Nitrate-N + Nitrite-N | g/m ³ | < 0.002 | - | - | - | - |
| Sulphate | g/m ³ | < 0.5 | - | - | - | - |
| Ethylene Glycol in Water | | | | | | |
| Ethylene glycol* | g/m ³ | < 4 | - | - | - | - |
| Propylene Glycol in Water | | | | | | |
| Propylene glycol* | g/m ³ | < 4 | - | - | - | - |
| Methanol in Water - Aqueous Solvents | | | | | | |
| Methanol* | g/m ³ | < 2 | - | - | - | - |



| Sample Type: Aqueous | | | | | | |
|--|--|----------|---|---|---|---|
| Sample Name: | TRC191620 (GND2632) 29-Mar-2019 9:15 am | | | | | |
| Lab Number: | 2151988.1 | | | | | |
| BTEX in Water by Headspace GC-MS | | | | | | |
| Benzene | g/m ³ | < 0.0010 | - | - | - | - |
| Toluene | g/m ³ | < 0.0010 | - | - | - | - |
| Ethylbenzene | g/m ³ | < 0.0010 | - | - | - | - |
| m&p-Xylene | g/m ³ | < 0.002 | - | - | - | - |
| o-Xylene | g/m ³ | < 0.0010 | - | - | - | - |
| Formaldehyde in Water by DNPH & LCMSMS | | | | | | |
| Formaldehyde | g/m ³ | < 0.02 | - | - | - | - |
| Gases in groundwater | | | | | | |
| Ethane | g/m ³ | 0.008 | - | - | - | - |
| Ethylene | g/m ³ | < 0.004 | - | - | - | - |
| Methane | g/m ³ | 9.2 | - | - | - | - |
| Total Petroleum Hydrocarbons in Water | | | | | | |
| C7 - C9 | g/m ³ | < 0.06 | - | - | - | - |
| C10 - C14 | g/m ³ | < 0.2 | - | - | - | - |
| C15 - C36 | g/m ³ | < 0.4 | - | - | - | - |
| Total hydrocarbons (C7 - C36) | g/m ³ | < 0.7 | - | - | - | - |

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

| Sample Type: Aqueous | | | |
|--|--|---|-----------|
| Test | Method Description | Default Detection Limit | Sample No |
| Ethylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 1 |
| Propylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 1 |
| Methanol in Water - Aqueous Solvents* | Direct injection, dual column GC-FID | 1.0 g/m ³ | 1 |
| BTEX in Water by Headspace GC-MS | Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] | 0.0010 - 0.002 g/m ³ | 1 |
| Formaldehyde in Water by DNPH & LCMSMS | DNPH derivatisation, extraction, LCMSMS | 0.02 g/m ³ | 1 |
| Gases in groundwater | Manual headspace creation and sub-sampling, GC-FID analysis. | 0.002 - 0.003 g/m ³ | 1 |
| Total Petroleum Hydrocarbons in Water | Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] | 0.06 - 0.7 g/m ³ | 1 |
| Filtration, Unpreserved | Sample filtration through 0.45µm membrane filter. | - | 1 |
| Total anions for anion/cation balance check | Calculation: sum of anions as mEq/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N, Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 23 rd ed. 2017. | 0.07 meq/L | 1 |
| Total cations for anion/cation balance check | Sum of cations as mEq/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H ⁺) also included in calculation if available. APHA 1030 E 23 rd ed. 2017. | 0.05 meq/L | 1 |
| pH | pH meter. APHA 4500-H ⁺ B 23 rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used. | 0.1 pH Units | 1 |
| Total Alkalinity | Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (modified for Alkalinity <20) 23 rd ed. 2017. | 1.0 g/m ³ as CaCO ₃ | 1 |
| Bicarbonate | Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO ₂ D 23 rd ed. 2017. | 1.0 g/m ³ at 25°C | 1 |

| Sample Type: Aqueous | | | |
|------------------------------|--|---|-----------|
| Test | Method Description | Default Detection Limit | Sample No |
| Total Hardness | Calculation from Calcium and Magnesium. APHA 2340 B 23 rd ed. 2017. | 1.0 g/m ³ as CaCO ₃ | 1 |
| Electrical Conductivity (EC) | Conductivity meter, 25°C. APHA 2510 B 23 rd ed. 2017. | 0.1 mS/m | 1 |
| Total Dissolved Solids (TDS) | Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 23 rd ed. 2017. | 10 g/m ³ | 1 |
| Sample Temperature* | Supplied by customer, otherwise 20°C. | 0.1 °C | 1 |
| Dissolved Barium | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.005 g/m ³ | 1 |
| Dissolved Calcium | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.05 g/m ³ | 1 |
| Dissolved Copper | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.0005 g/m ³ | 1 |
| Dissolved Iron | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.02 g/m ³ | 1 |
| Dissolved Magnesium | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.02 g/m ³ | 1 |
| Dissolved Manganese | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.0005 g/m ³ | 1 |
| Dissolved Mercury | 0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005. | 0.00008 g/m ³ | 1 |
| Dissolved Nickel | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.0005 g/m ³ | 1 |
| Dissolved Potassium | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.05 g/m ³ | 1 |
| Dissolved Sodium | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.02 g/m ³ | 1 |
| Dissolved Zinc | Filtered sample, ICP-MS, trace level. APHA 3125 B 23 rd ed. 2017. | 0.0010 g/m ³ | 1 |
| Bromide | Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 rd ed. 2017. | 0.05 g/m ³ | 1 |
| Chloride | Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 rd ed. 2017. | 0.5 g/m ³ | 1 |
| Nitrite-N | Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₂ ⁻ I (modified) 23 rd ed. 2017. | 0.002 g/m ³ | 1 |
| Nitrate-N | Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N. In-House. | 0.0010 g/m ³ | 1 |
| Nitrate-N + Nitrite-N | Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO ₃ ⁻ I (modified) 23 rd ed. 2017. | 0.002 g/m ³ | 1 |
| Sulphate | Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 rd ed. 2017. | 0.5 g/m ³ | 1 |
| C7 - C9 | Head Space, GCMS analysis. | 0.06 g/m ³ | 1 |

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.



Helena Bertram BSc
Client Services Manager - Environmental

Appendix III

Certificates of analysis
(hydraulic fracturing fluids)



Certificate of Analysis

Page 1 of 4

| | | | | |
|-----------------|--|--------------------------|------------------------|------|
| Client: | Greymouth Petroleum Limited | Lab No: | 2171287 | SPV1 |
| Contact: | Nakeysha Lammers C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312 | Date Received: | 07-May-2019 | |
| | | Date Reported: | 20-May-2019 | |
| | | Quote No: | 81870 | |
| | | Order No: | 245670 | |
| | | Client Reference: | Return Fluid Composite | |
| | | Submitted By: | Nakeysha Lammers | |

Sample Type: Saline

| | | | | | |
|---------------------|--|--|--|--|--|
| Sample Name: | Kowhai 5 Stim 3 - Composite Return Fluid | | | | |
| Lab Number: | 2171287.3 | | | | |

Individual Tests

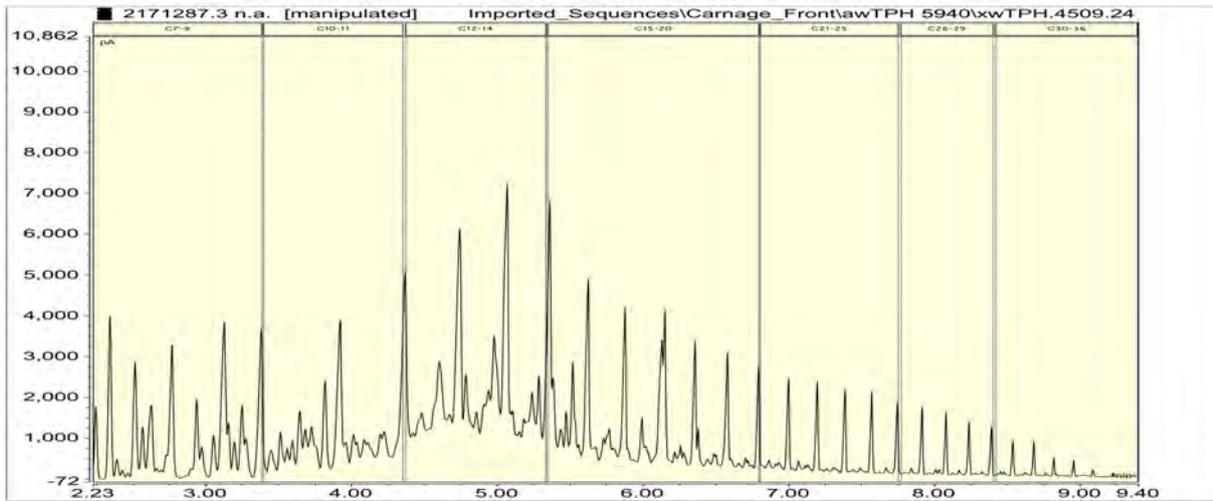
| | | | | | | |
|--------------------------------------|--|----------|---|---|---|---|
| pH* | pH Units | 7.8 | - | - | - | - |
| Total Alkalinity* | g/m ³ as CaCO ₃ | 1,140 | - | - | - | - |
| Analysis Temperature for Bicarbonate | °C | 21 | - | - | - | - |
| Bicarbonate | g/m ³ at Analysis Temperature | 904 | - | - | - | - |
| Total Hardness* | g/m ³ as CaCO ₃ | 176 | - | - | - | - |
| Electrical Conductivity (EC)* | mS/m | 1,526 | - | - | - | - |
| Total Dissolved Solids (TDS)* | g/m ³ | 11,600 | - | - | - | - |
| Dissolved Barium | g/m ³ | 41 | - | - | - | - |
| Dissolved Bromine | g/m ³ | 15.6 | - | - | - | - |
| Dissolved Calcium | g/m ³ | 52 | - | - | - | - |
| Dissolved Copper | g/m ³ | 0.036 | - | - | - | - |
| Dissolved Iron | g/m ³ | 25 | - | - | - | - |
| Dissolved Magnesium | g/m ³ | 11 | - | - | - | - |
| Dissolved Manganese | g/m ³ | 1.42 | - | - | - | - |
| Total Nickel | g/m ³ | 0.27 | - | - | - | - |
| Total Potassium | g/m ³ | 175 | - | - | - | - |
| Total Sodium | g/m ³ | 3,100 | - | - | - | - |
| Total Sulphur* | g/m ³ | 34 | - | - | - | - |
| Total Zinc | g/m ³ | 0.23 | - | - | - | - |
| Chloride* | g/m ³ | 4,700 | - | - | - | - |
| Nitrite-N | g/m ³ | < 0.0010 | - | - | - | - |
| Nitrate-N | g/m ³ | < 0.0010 | - | - | - | - |
| Nitrate* | g/m ³ | < 0.005 | - | - | - | - |
| Nitrate-N + Nitrite-N | g/m ³ | < 0.0010 | - | - | - | - |
| Sulphate* | g/m ³ | 101 | - | - | - | - |
| Ethylene Glycol in Water | | | | | | |
| Ethylene glycol* | g/m ³ | < 50 | - | - | - | - |
| Propylene Glycol in Water | | | | | | |
| Propylene glycol* | g/m ³ | < 50 | - | - | - | - |
| Methanol in Water - Aqueous Solvents | | | | | | |
| Methanol* | g/m ³ | < 20 | - | - | - | - |
| BTEX in Water by Headspace GC-MS | | | | | | |
| Benzene* | g/m ³ | 24 | - | - | - | - |
| Toluene* | g/m ³ | 165 | - | - | - | - |
| Ethylbenzene* | g/m ³ | 65 | - | - | - | - |
| m&p-Xylene* | g/m ³ | 340 | - | - | - | - |
| o-Xylene* | g/m ³ | 131 | - | - | - | - |



Sample Type: Saline

| | | | | | |
|--|--|--------|---|---|---|
| Sample Name: | Kowhai 5 Stim 3 - Composite Return Fluid | | | | |
| Lab Number: | 2171287.3 | | | | |
| Formaldehyde in Water by DNPH & LCMSMS | | | | | |
| Formaldehyde* | g/m ³ | < 0.15 | - | - | - |
| Total Petroleum Hydrocarbons in Water | | | | | |
| C7 - C9 | g/m ³ | 3,000 | - | - | - |
| C10 - C14* | g/m ³ | 4,300 | - | - | - |
| C15 - C36* | g/m ³ | 3,300 | - | - | - |
| Total hydrocarbons (C7 - C36) | g/m ³ | 10,600 | - | - | - |

2171287.3
 Kowhai 5 Stim 3 - Composite Return Fluid
 Client Chromatogram for TPH by FID



Analyst's Comments

It has been noted that the duplicate for the BTEX and TPH C7-C9 analysis on sample 2171287/3, which was run as part of our in-house QC procedure, showed greater variation than would normally be expected. This may reflect the heterogeneity of the sample.

Appendix No.1 - GNS report

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

| Test | Method Description | Default Detection Limit | Sample No |
|---|--|---------------------------------|-----------|
| Ethylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 3 |
| Propylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 3 |
| Methanol in Water - Aqueous Solvents* | Direct injection, dual column GC-FID | 1.0 g/m ³ | 3 |
| BTEX in Water by Headspace GC-MS* | Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] | 0.0010 - 0.002 g/m ³ | 3 |
| Formaldehyde in Water by DNPH & LCMSMS* | DNPH derivatisation, extraction, LCMSMS | 0.02 g/m ³ | 3 |
| Total Petroleum Hydrocarbons in Water* | Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] | 0.06 - 0.7 g/m ³ | 3 |
| Filtration, Unpreserved* | Sample filtration through 0.45µm membrane filter. | - | 3 |
| Total Digestion* | Boiling nitric acid digestion. APHA 3030 E (modified) 23 rd ed. 2017. | - | 3 |
| Total Digestion of Saline Samples* | Nitric acid digestion. APHA 3030 E (modified) 23 rd ed. 2017. | - | 3 |

| Sample Type: Saline | | | |
|---|--|---|-----------|
| Test | Method Description | Default Detection Limit | Sample No |
| pH* | pH meter. APHA 4500-H ⁺ B 23 rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used. | 0.1 pH Units | 3 |
| Total Alkalinity* | Saline water, Titration to pH 4.5. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. | 1.0 g/m ³ as CaCO ₃ | 3 |
| Analysis Temperature for Bicarbonate | Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei. | 1.0 °C | 3 |
| Bicarbonate | Bicarbonate (HCO ₃) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988. | 20 g/m ³ at Analysis Temperature | 3 |
| Total Hardness* | Calculation from Calcium and Magnesium. APHA 2340 B 23 rd ed. 2017. | 1.0 g/m ³ as CaCO ₃ | 3 |
| Electrical Conductivity (EC)* | Conductivity meter, 25°C. APHA 2510 B 23 rd ed. 2017. | 0.1 mS/m | 3 |
| Total Dissolved Solids (TDS)* | Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 23 rd ed. 2017. | 50 g/m ³ | 3 |
| Filtration for dissolved metals analysis* | Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 23 rd ed. 2017. | - | 3 |
| Dissolved Barium | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 0.0006 g/m ³ | 3 |
| Dissolved Bromine | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 0.10 g/m ³ | 3 |
| Dissolved Calcium | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 1.0 g/m ³ | 3 |
| Dissolved Copper | Filtered sample, ICP-MS, ultratrace. APHA 3125 B 23 rd ed. 2017. | 0.0010 g/m ³ | 3 |
| Dissolved Iron | Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23 rd ed. 2017. | 0.004 g/m ³ | 3 |
| Dissolved Magnesium | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 0.4 g/m ³ | 3 |
| Dissolved Manganese | Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23 rd ed. 2017. | 0.0010 g/m ³ | 3 |
| Total Nickel | Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 0.0070 g/m ³ | 3 |
| Total Potassium | Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 1.1 g/m ³ | 3 |
| Total Sodium | Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 0.42 g/m ³ | 3 |
| Total Sulphur* | Nitric acid digestion, ICP-OES (method may not fully account for H ₂ S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method. APHA 3120 B 23 rd ed. 2017. | 0.5 g/m ³ | 3 |
| Total Zinc | Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23 rd ed. 2017. | 0.0042 g/m ³ | 3 |
| Chloride* | Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 rd ed. 2017. | 0.5 g/m ³ | 3 |
| Nitrite-N | Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₂ ⁻ I (modified) 23 rd ed. 2017. | 0.0010 g/m ³ | 3 |
| Nitrate-N | Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N. In-House. | 0.0010 g/m ³ | 3 |
| Nitrate* | Calculation from Nitrate-N. | 0.005 g/m ³ | 3 |
| Nitrate-N + Nitrite-N | Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO ₃ ⁻ I (modified) 23 rd ed. 2017. | 0.0010 g/m ³ | 3 |
| Total Sulphate* | Calculation: from total sulphur. | 2 g/m ³ | 3 |
| C7 - C9 | Head Space, GCMS analysis. | 0.06 g/m ³ | 3 |

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental



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CERTIFICATE OF ANALYSIS
ENVSUBGNS_WAIRAKEI 84

Report No: 2019050802

Customer Ref:151790

Ara Heron
 RJ Hill Laboratories (Hamilton)
 Environmental Reports Officers
 Private Bag 3205
 Hamilton

GNS Lot No: 2019050802

GNS Sample No. 2019002445
Collection Date
Site ID 2171287.3
Field ID

| | | | | | |
|---------------------------------------|------|------------|---|---|---|
| pH | | 7.89 | - | - | - |
| Bicarbonate (Total) | mg/l | 904 | - | - | - |
| HCO ₃ Analysis Temperature | °C | 21 | - | - | - |
| HCO ₃ Analysis Date | | 10/05/2019 | - | - | - |

SUMMARY OF METHODS AND DETECTION LIMITS

The following table gives a brief description of the methods used to conduct the analyses on this report.
 The detection limits given below are those attainable in a relatively clean matrix.

| Parameter | Method | *Detection Limit | |
|---------------------|---|------------------|------|
| Bicarbonate (total) | HCO ₃ Titration Method ASTM Standards D513-82 Vol.11.01 1988 | 20 | mg/l |
| pH | Electrometric Method - APHA 4500-H+ B 23rd Edition 2017 | - | - |

*Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Notes: These samples were collected by yourselves (or your agent) and analysed as received at the laboratory. This report must not be reproduced, except in full, without the written consent of the signatory. Samples are held at the laboratory after reporting for a period of 2 to 6 months, dependent on sample type.

M. K. Appleby
 Moya Appleby
 Senior Technician



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 ACCREDITED LABORATORY

Tests marked with a †
 are not accredited and are
 outside the scope of the
 laboratory's accreditation



Certificate of Analysis

| | | | | |
|-----------------|--|--------------------------|------------------------|------|
| Client: | Greymouth Petroleum Limited | Lab No: | 2116008 | SPV1 |
| Contact: | Skye Loveridge-Easther C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312 | Date Received: | 30-Jan-2019 | |
| | | Date Reported: | 11-Feb-2019 | |
| | | Quote No: | 81870 | |
| | | Order No: | 245023 | |
| | | Client Reference: | Return Fluid Composite | |
| | | Submitted By: | Skye Loveridge-Easther | |

Sample Type: Saline

| | | | | | |
|---------------------|---|--|--|--|--|
| Sample Name: | Composite of Kow 5- Stim 1- Instant Flow Back, Kow 5- Stim 1- Middle Flow Back & Kow 5- Stim 1- End Flow Back | | | | |
| Lab Number: | 2116008.4 | | | | |

Individual Tests

| | | | | | | |
|--------------------------------------|--|----------|---|---|---|---|
| pH* | pH Units | 6.6 | - | - | - | - |
| Total Alkalinity* | g/m ³ as CaCO ₃ | 620 | - | - | - | - |
| Analysis Temperature for Bicarbonate | °C | 19.0 | - | - | - | - |
| Bicarbonate | g/m ³ at Analysis Temperature | 543 | - | - | - | - |
| Total Hardness* | g/m ³ as CaCO ₃ | 400 | - | - | - | - |
| Electrical Conductivity (EC)* | mS/m | 2,160 | - | - | - | - |
| Total Dissolved Solids (TDS)* | g/m ³ | 13,600 | - | - | - | - |
| Dissolved Barium | g/m ³ | 83 | - | - | - | - |
| Dissolved Bromine | g/m ³ | 21 | - | - | - | - |
| Dissolved Calcium | g/m ³ | 136 | - | - | - | - |
| Dissolved Copper | g/m ³ | 0.018 | - | - | - | - |
| Dissolved Iron | g/m ³ | 3.9 | - | - | - | - |
| Dissolved Magnesium | g/m ³ | 14 | - | - | - | - |
| Dissolved Manganese | g/m ³ | 5.2 | - | - | - | - |
| Total Nickel | g/m ³ | 0.076 | - | - | - | - |
| Total Potassium | g/m ³ | 260 | - | - | - | - |
| Total Sodium | g/m ³ | 4,300 | - | - | - | - |
| Total Sulphur* | g/m ³ | 24 | - | - | - | - |
| Total Zinc | g/m ³ | 0.144 | - | - | - | - |
| Chloride* | g/m ³ | 6,900 | - | - | - | - |
| Nitrite-N | g/m ³ | < 0.0010 | - | - | - | - |
| Nitrate-N | g/m ³ | 0.0027 | - | - | - | - |
| Nitrate* | g/m ³ | 0.012 | - | - | - | - |
| Nitrate-N + Nitrite-N | g/m ³ | 0.0034 | - | - | - | - |
| Sulphate* | g/m ³ | 73 | - | - | - | - |
| Ethylene Glycol in Water | | | | | | |
| Ethylene glycol* | g/m ³ | < 20 | - | - | - | - |
| Propylene Glycol in Water | | | | | | |
| Propylene glycol* | g/m ³ | < 20 | - | - | - | - |
| Methanol in Water - Aqueous Solvents | | | | | | |
| Methanol* | g/m ³ | < 20 | - | - | - | - |



Sample Type: Saline

| | | | | | |
|---------------------|---|--|--|--|--|
| Sample Name: | Composite of Kow 5- Stim 1- Instant Flow Back, Kow 5- Stim 1- Middle Flow Back & Kow 5- Stim 1- End Flow Back | | | | |
| Lab Number: | 2116008.4 | | | | |

BTEX in Water by Headspace GC-MS

| | | | | | | |
|---------------|------------------|------|---|---|---|---|
| Benzene* | g/m ³ | 11.8 | - | - | - | - |
| Toluene* | g/m ³ | 18.4 | - | - | - | - |
| Ethylbenzene* | g/m ³ | 2.3 | - | - | - | - |
| m&p-Xylene* | g/m ³ | 10.4 | - | - | - | - |
| o-Xylene* | g/m ³ | 3.7 | - | - | - | - |

Formaldehyde in Water by DNPH & LCMSMS

| | | | | | | |
|---------------|------------------|-------|---|---|---|---|
| Formaldehyde* | g/m ³ | < 1.5 | - | - | - | - |
|---------------|------------------|-------|---|---|---|---|

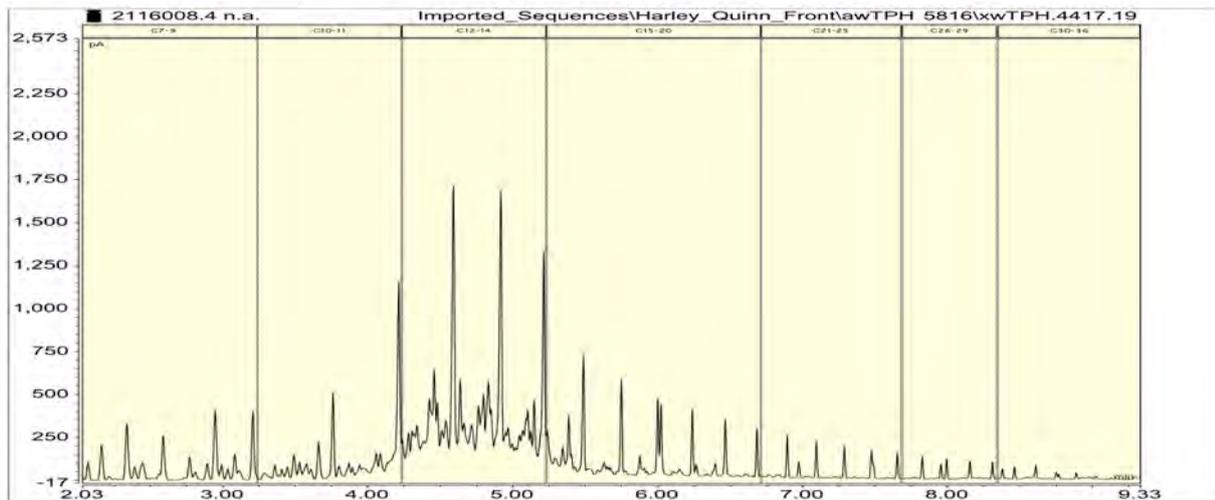
Total Petroleum Hydrocarbons in Water

| | | | | | | |
|-------------------------------|------------------|-------|---|---|---|---|
| C7 - C9 | g/m ³ | 96 | - | - | - | - |
| C10 - C14* | g/m ³ | 670 | - | - | - | - |
| C15 - C36* | g/m ³ | 280 | - | - | - | - |
| Total hydrocarbons (C7 - C36) | g/m ³ | 1,050 | - | - | - | - |

2116008.4

Composite of Kow 5- Stim 1- Instant Flow Back, Kow 5- Stim 1- Middle Flow Back & Kow 5- Stim 1- End Flow Back

Client Chromatogram for TPH by FID



Analyst's Comments

Appendix No.1 - Tests subcontracted to GNS Science

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

| Test | Method Description | Default Detection Limit | Sample No |
|---|--|---------------------------------|-----------|
| Ethylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 4 |
| Propylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 4 |
| Methanol in Water - Aqueous Solvents* | Direct injection, dual column GC-FID | 1.0 g/m ³ | 4 |
| BTEX in Water by Headspace GC-MS* | Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] | 0.0010 - 0.002 g/m ³ | 4 |
| Formaldehyde in Water by DNPH & LCMSMS* | DNPH derivatisation, extraction, LCMSMS | 0.02 g/m ³ | 4 |
| Total Petroleum Hydrocarbons in Water* | Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] | 0.06 - 0.7 g/m ³ | 4 |

| Sample Type: Saline | | | |
|---|--|---|-----------|
| Test | Method Description | Default Detection Limit | Sample No |
| Filtration, Unpreserved* | Sample filtration through 0.45µm membrane filter. | - | 4 |
| Total Digestion* | Boiling nitric acid digestion. APHA 3030 E (modified) 23 rd ed. 2017. | - | 4 |
| Total Digestion of Saline Samples* | Nitric acid digestion. APHA 3030 E (modified) 23 rd ed. 2017. | - | 4 |
| pH* | pH meter. APHA 4500-H ⁺ B 23 rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used. | 0.1 pH Units | 4 |
| Total Alkalinity* | Saline water, Titration to pH 4.5. | 1.0 g/m ³ as CaCO ₃ | 4 |
| Analysis Temperature for Bicarbonate | Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei. | 1.0 °C | 4 |
| Bicarbonate | Bicarbonate (HCO ₃) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988. | 20 g/m ³ at Analysis Temperature | 4 |
| Total Hardness* | Calculation from Calcium and Magnesium. APHA 2340 B 23 rd ed. 2017. | 1.0 g/m ³ as CaCO ₃ | 4 |
| Electrical Conductivity (EC)* | Conductivity meter, 25°C. APHA 2510 B 23 rd ed. 2017. | 0.1 mS/m | 4 |
| Total Dissolved Solids (TDS)* | Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 23 rd ed. 2017. | 50 g/m ³ | 4 |
| Filtration for dissolved metals analysis* | Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 23 rd ed. 2017. | - | 4 |
| Dissolved Barium | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 0.0006 g/m ³ | 4 |
| Dissolved Bromine | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 0.10 g/m ³ | 4 |
| Dissolved Calcium | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 1.0 g/m ³ | 4 |
| Dissolved Copper | Filtered sample, ICP-MS, ultratrace. APHA 3125 B 23 rd ed. 2017. | 0.0010 g/m ³ | 4 |
| Dissolved Iron | Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23 rd ed. 2017. | 0.004 g/m ³ | 4 |
| Dissolved Magnesium | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 0.4 g/m ³ | 4 |
| Dissolved Manganese | Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23 rd ed. 2017. | 0.0010 g/m ³ | 4 |
| Total Nickel | Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 0.0070 g/m ³ | 4 |
| Total Potassium | Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 1.1 g/m ³ | 4 |
| Total Sodium | Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 0.42 g/m ³ | 4 |
| Total Sulphur* | Nitric acid digestion, ICP-OES (method may not fully account for H ₂ S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method. APHA 3120 B 23 rd ed. 2017. | 0.5 g/m ³ | 4 |
| Total Zinc | Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23 rd ed. 2017. | 0.0042 g/m ³ | 4 |
| Chloride* | Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 rd ed. 2017. | 0.5 g/m ³ | 4 |
| Nitrite-N | Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₂ ⁻ I (modified) 23 rd ed. 2017. | 0.0010 g/m ³ | 4 |
| Nitrate-N | Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N. In-House. | 0.0010 g/m ³ | 4 |
| Nitrate* | Calculation from Nitrate-N. | 0.010 g/m ³ | 4 |
| Nitrate-N + Nitrite-N | Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO ₃ ⁻ I (modified) 23 rd ed. 2017. | 0.0010 g/m ³ | 4 |
| Total Sulphate* | Calculation: from total sulphur. | 2 g/m ³ | 4 |
| C7 - C9 | Head Space, GCMS analysis. | 0.06 g/m ³ | 4 |

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Client Services Manager - Environmental



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Email: w.labmanager@gns.cri.nz

EnvSubGNS_Wairakei 77

Report No: 2019013101

Customer Ref:151308

RJ Hill Laboratories (Hamilton)
Environmental Reports Officers
Private Bag 3205
Hamilton

GNS Lot No: 2019013101

GNS Sample No. 2019000566
Collection Date
Site ID 2116008.4
Field ID

| | | | | |
|--|------------|---|---|---|
| pH | 6.57 | - | - | - |
| Bicarbonate (Total) mg/l | 543 | - | - | - |
| HCO ₃ Analysis Temperature °C | 19 | - | - | - |
| HCO ₃ Analysis Date | 31/01/2019 | - | - | - |

SUMMARY OF METHODS AND DETECTION LIMITS

The following table gives a brief description of the methods used to conduct the analyses on this report. The detection limits given below are those attainable in a relatively clean matrix.

| Parameter | Method | *Detection Limit | |
|---------------------|---|------------------|------|
| Bicarbonate (total) | HCO ₃ Titration Method ASTM Standards D513-82 Vol.11.01 1988 | 20 | mg/l |
| pH | Electrometric Method - APHA 4500-H+ B 23rd Edition 2017 | - | - |

*Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Notes: These samples were collected by yourselves (or your agent) and analysed as received at the laboratory. This report must not be reproduced, except in full, without the written consent of the signatory. Samples are held at the laboratory after reporting for a period of 2 to 6 months, dependent on sample type.

Ann Noddings
Senior Technician



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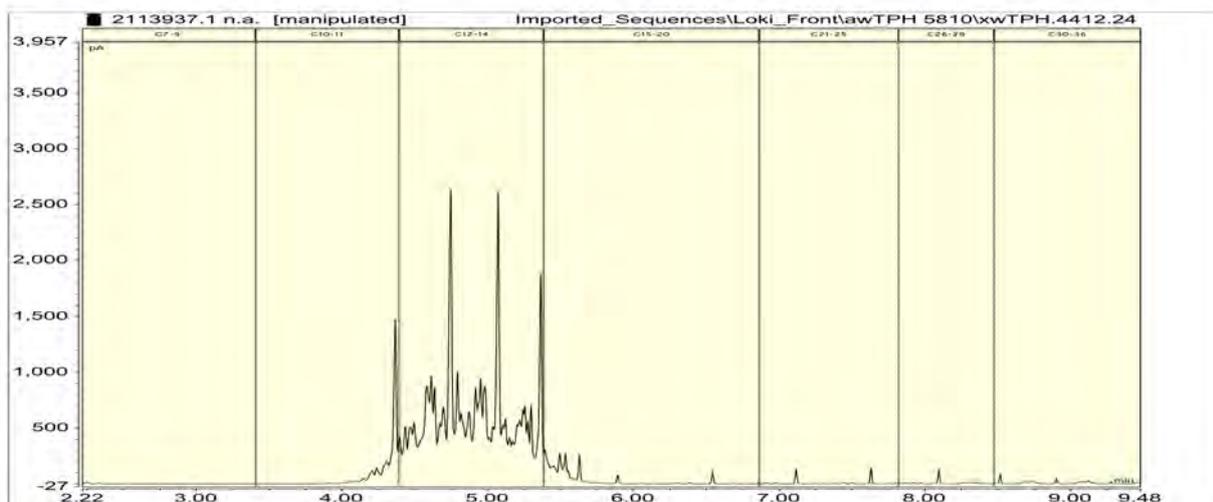
Certificate of Analysis

| | | | | |
|-----------------|--|--------------------------|------------------------------------|------|
| Client: | Greymouth Petroleum Limited | Lab No: | 2113937 | SPV1 |
| Contact: | Skye Loveridge-Easther C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312 | Date Received: | 25-Jan-2019 | |
| | | Date Reported: | 05-Feb-2019 | |
| | | Quote No: | 85159 | |
| | | Order No: | 245022 | |
| | | Client Reference: | Hydraulic fracturing fluid testing | |
| | | Submitted By: | Skye Loveridge-Easther | |

Sample Type: Aqueous

| | | | | | |
|---------------------------------------|---|---------|---|---|---|
| Sample Name: | Kowhai 5 - Stim 1 Pre-Pumped HF Fluid 22-Jan-2019 | | | | |
| Lab Number: | 2113937.1 | | | | |
| Ethylene Glycol in Water | | | | | |
| Ethylene glycol* | g/m ³ | < 20 | - | - | - |
| Propylene Glycol in Water | | | | | |
| Propylene glycol* | g/m ³ | < 20 | - | - | - |
| Methanol in Water - Aqueous Solvents | | | | | |
| Methanol* | g/m ³ | < 20 | - | - | - |
| BTEX in Water by Headspace GC-MS | | | | | |
| Benzene | g/m ³ | < 0.010 | - | - | - |
| Toluene | g/m ³ | < 0.010 | - | - | - |
| Ethylbenzene | g/m ³ | < 0.010 | - | - | - |
| m&p-Xylene | g/m ³ | < 0.02 | - | - | - |
| o-Xylene | g/m ³ | < 0.010 | - | - | - |
| Total Petroleum Hydrocarbons in Water | | | | | |
| C7 - C9 | g/m ³ | < 0.6 | - | - | - |
| C10 - C14 | g/m ³ | 2,300 | - | - | - |
| C15 - C36 | g/m ³ | 210 | - | - | - |
| Total hydrocarbons (C7 - C36) | g/m ³ | 2,500 | - | - | - |

2113937.1
Kowhai 5 - Stim 1 Pre-Pumped HF Fluid 22-Jan-2019
Client Chromatogram for TPH by FID



Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

| Sample Type: Aqueous | | | |
|--|--|---------------------------------|-----------|
| Test | Method Description | Default Detection Limit | Sample No |
| Ethylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 1 |
| Propylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 1 |
| Methanol in Water - Aqueous Solvents* | Direct injection, dual column GC-FID | 1.0 g/m ³ | 1 |
| BTEX in Water by Headspace GC-MS | Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] | 0.0010 - 0.002 g/m ³ | 1 |
| Total Petroleum Hydrocarbons in Water* | Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] | 0.06 - 0.7 g/m ³ | 1 |
| C7 - C9 | Head Space, GCMS analysis. | 0.06 g/m ³ | 1 |

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Carole Rodgers-Carroll BA, NZCS
Client Services Manager - Environmental



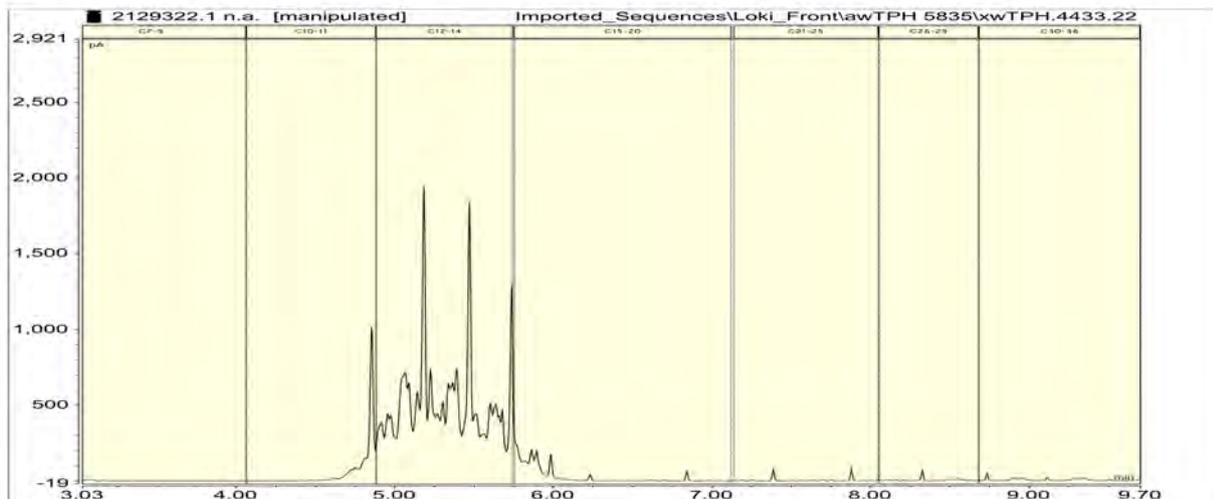
Certificate of Analysis

| | | | | |
|-----------------|--|--------------------------|------------------------------------|------|
| Client: | Greymouth Petroleum Limited | Lab No: | 2129322 | SPV1 |
| Contact: | Skye Loveridge-Easther C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312 | Date Received: | 22-Feb-2019 | |
| | | Date Reported: | 28-Feb-2019 | |
| | | Quote No: | 85159 | |
| | | Order No: | 245412 | |
| | | Client Reference: | Hydraulic fracturing fluid testing | |
| | | Submitted By: | Skye Loveridge-Easther | |

Sample Type: Aqueous

| | | | | | | |
|---------------------------------------|---|---------|---|---|---|---|
| Sample Name: | Kow 5 - STIM 2 Prepumped HF 14-Feb-2019 | | | | | |
| Lab Number: | 2129322.1 | | | | | |
| Ethylene Glycol in Water | | | | | | |
| Ethylene glycol* | g/m ³ | < 4 | - | - | - | - |
| Propylene Glycol in Water | | | | | | |
| Propylene glycol* | g/m ³ | < 4 | - | - | - | - |
| Methanol in Water - Aqueous Solvents | | | | | | |
| Methanol* | g/m ³ | < 30 | - | - | - | - |
| BTEX in Water by Headspace GC-MS | | | | | | |
| Benzene | g/m ³ | < 0.010 | - | - | - | - |
| Toluene | g/m ³ | < 0.010 | - | - | - | - |
| Ethylbenzene | g/m ³ | < 0.010 | - | - | - | - |
| m&p-Xylene | g/m ³ | < 0.02 | - | - | - | - |
| o-Xylene | g/m ³ | < 0.010 | - | - | - | - |
| Total Petroleum Hydrocarbons in Water | | | | | | |
| C7 - C9 | g/m ³ | < 0.6 | - | - | - | - |
| C10 - C14 | g/m ³ | 2,000 | - | - | - | - |
| C15 - C36 | g/m ³ | 167 | - | - | - | - |
| Total hydrocarbons (C7 - C36) | g/m ³ | 2,200 | - | - | - | - |

2129322.1
Kow 5 - STIM 2 Prepumped HF 14-Feb-2019
Client Chromatogram for TPH by FID



Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

| Sample Type: Aqueous | | | |
|--|--|---------------------------------|-----------|
| Test | Method Description | Default Detection Limit | Sample No |
| Ethylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 1 |
| Propylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 1 |
| Methanol in Water - Aqueous Solvents* | Direct injection, dual column GC-FID | 1.0 g/m ³ | 1 |
| BTEX in Water by Headspace GC-MS | Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] | 0.0010 - 0.002 g/m ³ | 1 |
| Total Petroleum Hydrocarbons in Water* | Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] | 0.06 - 0.7 g/m ³ | 1 |
| C7 - C9 | Head Space, GCMS analysis. | 0.06 g/m ³ | 1 |

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Ara Heron BSc (Tech)
Client Services Manager - Environmental



Certificate of Analysis

| | | | | |
|-----------------|--|--------------------------|------------------------------------|------|
| Client: | Greymouth Petroleum Limited | Lab No: | 2143163 | SPV1 |
| Contact: | Skye Loveridge-Easther C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312 | Date Received: | 16-Mar-2019 | |
| | | Date Reported: | 26-Mar-2019 | |
| | | Quote No: | 85159 | |
| | | Order No: | 245671 | |
| | | Client Reference: | Hydraulic fracturing fluid testing | |
| | | Submitted By: | Skye Loveridge-Easther | |

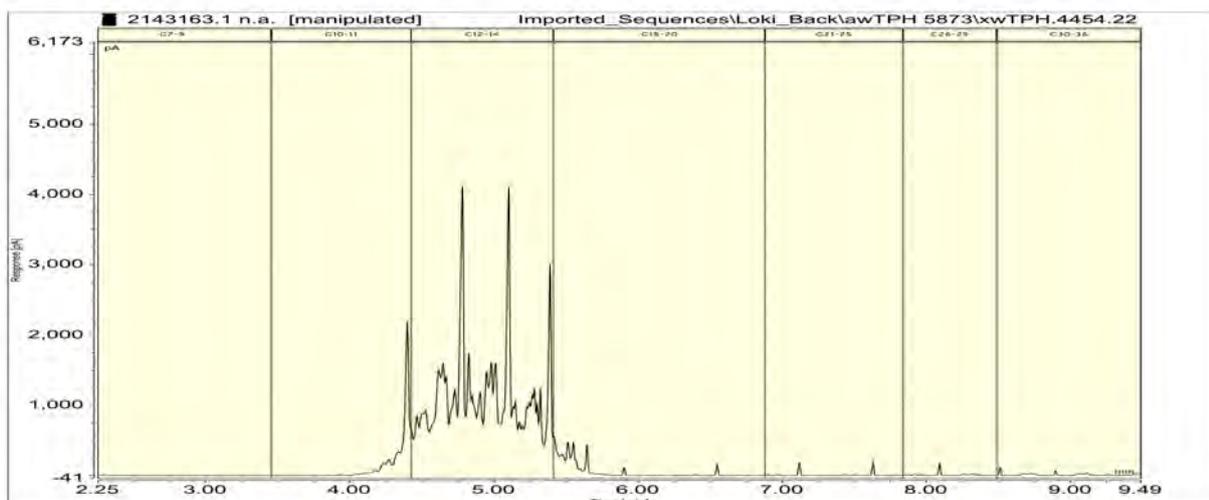
Sample Type: Aqueous

| | | | | | | |
|---------------------------------------|---|---------|---|---|---|---|
| Sample Name: | Kow 5 - Stim 3 Prepumped HF Fluid 11-Mar-2019 | | | | | |
| Lab Number: | 2143163.1 | | | | | |
| Ethylene Glycol in Water | | | | | | |
| Ethylene glycol* | g/m ³ | < 20 | - | - | - | - |
| Propylene Glycol in Water | | | | | | |
| Propylene glycol* | g/m ³ | < 20 | - | - | - | - |
| Methanol in Water - Aqueous Solvents | | | | | | |
| Methanol* | g/m ³ | < 2 | - | - | - | - |
| BTEX in Water by Headspace GC-MS | | | | | | |
| Benzene | g/m ³ | < 0.010 | - | - | - | - |
| Toluene | g/m ³ | < 0.010 | - | - | - | - |
| Ethylbenzene | g/m ³ | < 0.010 | - | - | - | - |
| m&p-Xylene | g/m ³ | < 0.02 | - | - | - | - |
| o-Xylene | g/m ³ | < 0.010 | - | - | - | - |
| Total Petroleum Hydrocarbons in Water | | | | | | |
| C7 - C9 | g/m ³ | < 0.6 | - | - | - | - |
| C10 - C14 | g/m ³ | 3,000 | - | - | - | - |
| C15 - C36 | g/m ³ | 230 | - | - | - | - |
| Total hydrocarbons (C7 - C36) | g/m ³ | 3,300 | - | - | - | - |

2143163.1

Kow 5 - Stim 3 Prepumped HF Fluid 11-Mar-2019

Client Chromatogram for TPH by FID



Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

| Sample Type: Aqueous | | | |
|--|--|---------------------------------|-----------|
| Test | Method Description | Default Detection Limit | Sample No |
| Ethylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 1 |
| Propylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 1 |
| Methanol in Water - Aqueous Solvents* | Direct injection, dual column GC-FID | 1.0 g/m ³ | 1 |
| BTEX in Water by Headspace GC-MS | Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] | 0.0010 - 0.002 g/m ³ | 1 |
| Total Petroleum Hydrocarbons in Water* | Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] | 0.06 - 0.7 g/m ³ | 1 |
| C7 - C9 | Head Space, GCMS analysis. | 0.06 g/m ³ | 1 |

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Ara Heron BSc (Tech)
Client Services Manager - Environmental



Certificate of Analysis

| | | | | |
|-----------------|---------------------------------|--------------------------|------------------------|-----------|
| Client: | Greymouth Petroleum Limited | Lab No: | 2129321 | SPv2 |
| Contact: | Skye Loveridge-Easther | Date Received: | 22-Feb-2019 | |
| | C/- Greymouth Petroleum Limited | Date Reported: | 06-Mar-2019 | (Amended) |
| | 14 Connett Road West | Quote No: | 81870 | |
| | Bell Block | Order No: | 245413 | |
| | New Plymouth 4312 | Client Reference: | Return Fluid Composite | |
| | | Submitted By: | Skye Loveridge-Easther | |

Sample Type: Saline

| | | | | | |
|---------------------|---|--|--|--|--|
| Sample Name: | Kow 5 - Stim 2 - Composite Return Fluid | | | | |
| Lab Number: | 2129321.4 | | | | |

Individual Tests

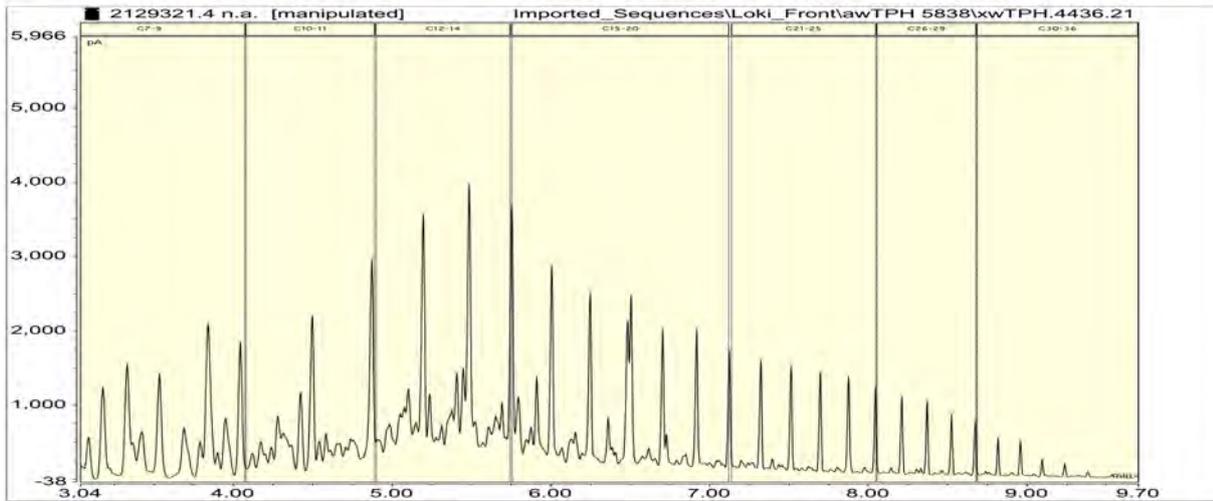
| | | | | | | |
|--------------------------------------|--|-----------|---|---|---|---|
| pH* | pH Units | 6.7 | - | - | - | - |
| Total Alkalinity* | g/m ³ as CaCO ₃ | 600 | - | - | - | - |
| Analysis Temperature for Bicarbonate | °C | 22 | - | - | - | - |
| Bicarbonate | g/m ³ at Analysis Temperature | 530 | - | - | - | - |
| Total Hardness* | g/m ³ as CaCO ₃ | 350 | - | - | - | - |
| Electrical Conductivity (EC)* | mS/m | 1,921 | - | - | - | - |
| Total Dissolved Solids (TDS)* | g/m ³ | 13,100 | - | - | - | - |
| Dissolved Barium | g/m ³ | 66 | - | - | - | - |
| Dissolved Bromine | g/m ³ | 18.2 | - | - | - | - |
| Dissolved Calcium | g/m ³ | 120 | - | - | - | - |
| Dissolved Copper | g/m ³ | 0.032 | - | - | - | - |
| Dissolved Iron | g/m ³ | 11.5 | - | - | - | - |
| Dissolved Magnesium | g/m ³ | 13 | - | - | - | - |
| Dissolved Manganese | g/m ³ | 3.9 | - | - | - | - |
| Total Nickel | g/m ³ | 0.24 | - | - | - | - |
| Total Potassium | g/m ³ | 250 | - | - | - | - |
| Total Sodium | g/m ³ | 3,800 | - | - | - | - |
| Total Sulphur* | g/m ³ | 29 | - | - | - | - |
| Total Zinc | g/m ³ | 0.65 | - | - | - | - |
| Chloride* | g/m ³ | 6,900 | - | - | - | - |
| Nitrite-N | g/m ³ | < 0.10 #1 | - | - | - | - |
| Nitrate-N | g/m ³ | < 0.10 | - | - | - | - |
| Nitrate* | g/m ³ | < 0.5 | - | - | - | - |
| Nitrate-N + Nitrite-N | g/m ³ | < 0.10 #1 | - | - | - | - |
| Sulphate* | g/m ³ | 87 | - | - | - | - |
| Ethylene Glycol in Water | | | | | | |
| Ethylene glycol* | g/m ³ | < 20 | - | - | - | - |
| Propylene Glycol in Water | | | | | | |
| Propylene glycol* | g/m ³ | < 20 | - | - | - | - |
| Methanol in Water - Aqueous Solvents | | | | | | |
| Methanol* | g/m ³ | < 30 | - | - | - | - |
| BTEX in Water by Headspace GC-MS | | | | | | |
| Benzene* | g/m ³ | 20 | - | - | - | - |
| Toluene* | g/m ³ | 34 | - | - | - | - |
| Ethylbenzene* | g/m ³ | 7.8 | - | - | - | - |
| m&p-Xylene* | g/m ³ | 22 | - | - | - | - |
| o-Xylene* | g/m ³ | 7.5 | - | - | - | - |



Sample Type: Saline

| | | | | | |
|--|---|--------|---|---|---|
| Sample Name: | Kow 5 - Stim 2 - Composite Return Fluid | | | | |
| Lab Number: | 2129321.4 | | | | |
| Formaldehyde in Water by DNPH & LCMSMS | | | | | |
| Formaldehyde* | g/m ³ | < 0.15 | - | - | - |
| Total Petroleum Hydrocarbons in Water | | | | | |
| C7 - C9 | g/m ³ | 148 | - | - | - |
| C10 - C14* | g/m ³ | 990 | - | - | - |
| C15 - C36* | g/m ³ | 890 | - | - | - |
| Total hydrocarbons (C7 - C36) | g/m ³ | 2,000 | - | - | - |

2129321.4
 Kow 5 - Stim 2 - Composite Return Fluid
 Client Chromatogram for TPH by FID



Analyst's Comments

#1 Due to the nature of this sample a dilution was performed prior to analysis, resulting in a detection limit higher than that normally achieved for the NO₂N, NO₃N and NO_xN analysis.

Amended Report: This certificate of analysis replaces an earlier certificate issued on 06 Mar 2019 at 2:08 pm
 Reason for amendment: The sample name has been amended, at the request of the client.

Appendix No.1 - Bicarbonate and Temperature Report

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

| Test | Method Description | Default Detection Limit | Sample No |
|---|--|---------------------------------|-----------|
| Ethylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 4 |
| Propylene Glycol in Water* | Direct injection, dual column GC-FID | 4 g/m ³ | 4 |
| Methanol in Water - Aqueous Solvents* | Direct injection, dual column GC-FID | 1.0 g/m ³ | 4 |
| BTEX in Water by Headspace GC-MS* | Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] | 0.0010 - 0.002 g/m ³ | 4 |
| Formaldehyde in Water by DNPH & LCMSMS* | DNPH derivatisation, extraction, LCMSMS | 0.02 g/m ³ | 4 |
| Total Petroleum Hydrocarbons in Water* | Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] | 0.06 - 0.7 g/m ³ | 4 |
| Filtration, Unpreserved* | Sample filtration through 0.45µm membrane filter. | - | 4 |
| Total Digestion* | Boiling nitric acid digestion. APHA 3030 E (modified) 23 rd ed. 2017. | - | 4 |
| Total Digestion of Saline Samples* | Nitric acid digestion. APHA 3030 E (modified) 23 rd ed. 2017. | - | 4 |

| Sample Type: Saline | | | |
|---|--|---|-----------|
| Test | Method Description | Default Detection Limit | Sample No |
| pH* | pH meter. APHA 4500-H ⁺ B 23 rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used. | 0.1 pH Units | 4 |
| Total Alkalinity* | Saline water, Titration to pH 4.5. | 1.0 g/m ³ as CaCO ₃ | 4 |
| Analysis Temperature for Bicarbonate | Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei. | 1.0 °C | 4 |
| Bicarbonate | Bicarbonate (HCO ₃) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988. | 20 g/m ³ at Analysis Temperature | 4 |
| Total Hardness* | Calculation from Calcium and Magnesium. APHA 2340 B 23 rd ed. 2017. | 1.0 g/m ³ as CaCO ₃ | 4 |
| Electrical Conductivity (EC)* | Conductivity meter, 25°C. APHA 2510 B 23 rd ed. 2017. | 0.1 mS/m | 4 |
| Total Dissolved Solids (TDS)* | Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 23 rd ed. 2017. | 50 g/m ³ | 4 |
| Filtration for dissolved metals analysis* | Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 23 rd ed. 2017. | - | 4 |
| Dissolved Barium | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 0.0006 g/m ³ | 4 |
| Dissolved Bromine | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 0.10 g/m ³ | 4 |
| Dissolved Calcium | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 1.0 g/m ³ | 4 |
| Dissolved Copper | Filtered sample, ICP-MS, ultratrace. APHA 3125 B 23 rd ed. 2017. | 0.0010 g/m ³ | 4 |
| Dissolved Iron | Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23 rd ed. 2017. | 0.004 g/m ³ | 4 |
| Dissolved Magnesium | Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 0.4 g/m ³ | 4 |
| Dissolved Manganese | Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23 rd ed. 2017. | 0.0010 g/m ³ | 4 |
| Total Nickel | Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 0.0070 g/m ³ | 4 |
| Total Potassium | Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 1.1 g/m ³ | 4 |
| Total Sodium | Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23 rd ed. 2017. | 0.42 g/m ³ | 4 |
| Total Sulphur* | Nitric acid digestion, ICP-OES (method may not fully account for H ₂ S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method. APHA 3120 B 23 rd ed. 2017. | 0.5 g/m ³ | 4 |
| Total Zinc | Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23 rd ed. 2017. | 0.0042 g/m ³ | 4 |
| Chloride* | Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23 rd ed. 2017. | 0.5 g/m ³ | 4 |
| Nitrite-N | Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₂ ⁻ I (modified) 23 rd ed. 2017. | 0.0010 g/m ³ | 4 |
| Nitrate-N | Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N. In-House. | 0.0010 g/m ³ | 4 |
| Nitrate* | Calculation from Nitrate-N. | 0.010 g/m ³ | 4 |
| Nitrate-N + Nitrite-N | Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO ₃ ⁻ I (modified) 23 rd ed. 2017. | 0.0010 g/m ³ | 4 |
| Total Sulphate* | Calculation: from total sulphur. | 2 g/m ³ | 4 |
| C7 - C9 | Head Space, GCMS analysis. | 0.06 g/m ³ | 4 |

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Helena Bertram BSc
Client Services Manager - Environmental



ANALYTICAL LABORATORY
Private Bag 2000, Taupo
Phone: (07) 374 8211
Fax: (07) 374 8199
Email: w.labmanager@gns.cri.nz

ENVSUBGNS_WAIRAKEI 81

Report No: 2019022605

Customer Ref:151408

RJ Hill Laboratories (Hamilton)
Environmental Reports Officers
Private Bag 3205
Hamilton

GNS Lot No: 2019022605

GNS Sample No. 2019001100
Collection Date
Site ID 2129321.4
Field ID

| | | | | | |
|---------------------------------------|------|------------|---|---|---|
| pH | | 7.18 | - | - | - |
| Bicarbonate (Total) | mg/l | 530 | - | - | - |
| HCO ₃ Analysis Temperature | °C | 22 | - | - | - |
| HCO ₃ Analysis Date | | 27/02/2019 | - | - | - |

SUMMARY OF METHODS AND DETECTION LIMITS

The following table gives a brief description of the methods used to conduct the analyses on this report.
The detection limits given below are those attainable in a relatively clean matrix.

| Parameter | Method | *Detection Limit | |
|---------------------|---|------------------|------|
| Bicarbonate (total) | HCO ₃ Titration Method ASTM Standards D513-82 Vol.11.01 1988 | 20 | mg/l |
| pH | Electrometric Method - APHA 4500-H+ B 23rd Edition 2017 | - | - |

*Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Notes: These samples were collected by yourselves (or your agent) and analysed as received at the laboratory. This report must not be reproduced, except in full, without the written consent of the signatory. Samples are held at the laboratory after reporting for a period of 2 to 6 months, dependent on sample type.

Ann Noddings
Senior Technician



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ACCREDITED LABORATORY

Tests marked with a †
are not accredited and are
outside the scope of the
laboratory's accreditation